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"THE PRACTICAL CHARACTER OF THE NAVAL WAR COLLEGE."

An Address delivered at the Opening of the Annual Session, September 6, 1892.

By CAPTAIN A. T. MAHAN, President of the College.

LADIES AND GENTLEMEN:—It had been my hope, and I may say my expectation, that upon this occasion when, after a prolonged, and to some extent disastrous, interruption of its career of usefulness, the War College is about to resume its course under new auspices and with better hopes, the opening ceremonies would have been signalized by a formal address from the Assistant Secretary of the Navy. To him, under the Secretary himself, is mainly due that a start this year has been made at all. He has been in past years, and from the very origin of the College, closely connected with it, both, generally, by sympathy with its ideas and, especially, as a most able lecturer upon international law; and it is probable that some

of those now among my hearers may have been so fortunate as to hear, at former sessions, his admirable exposition of its principles, with particular reference to the circumstances of naval officers, and the perplexities which they may encounter. This association of the past, together with his present official position, combined to indicate him pointedly as the most proper person to deliver this opening address; for, in addition to the strong personal reasons I have mentioned, his presence would have been the manifest token of the cordial interest now extended by the Navy Department, the want of which was keenly felt in the first strong and, I may boldly say, not unsuccessful effort to develop the art of naval war. The premature blight that fell upon our early endeavors did not wholly obliterate the recognition of the decisive advance made during our brief and checkered existence. Of this I have had the assurance, both directly by word and indirectly by action, from so many that attended the former courses, that no fond self-deception can account for the conviction I now express, of the results obtained by those of whom I was for most of the time the nominal head.

To my urgent and repeated requests the Assistant Secretary gave no more than a conditional promise; and I owe only to myself that I so far depended upon it as to have deferred to the last three days such hurried preparations as I have made, personally, to meet this audience, and, so far as in me lies, replace the loss which we have to regret. To the embarrassment of scanty time, for which I have to blame my want of prevision, is added in my case the fact that I have already, on a former opening, delivered an address in which I explained at some length the objects and aims of the College from my own point of view, which I may add was that of my then immediate superior, the Chief of the Bureau of Navigation, who to-day is with us as the commander of the Squadron of Evolution. Had that address then gone no further, it might now, after the lapse of four years, have been resurrected like the sermon from the proverbial barrel and done duty again; but having incautiously been allowed to pass into print, and somewhat widely distributed within the service, this resource is not now open to me.

Like all new departures, however, the College has to encounter not merely constructional difficulties, the friction which inevitably attends every effort to do something which has not been done before, and which formed the subject of my former address. It has to

encounter the more formidable, because more discouraging, obstacles of direct objection, based often on reasonable grounds; more often, perhaps, on unconsidered prejudice. Of the former, the reasonable criticism, I shall now only say that I trust there will always be found in the College representatives an open and dispassionate mind, ready to receive, consider and profit by suggestions from whomsoever coming. I propose to-day to devote my remarks only to those objections which, while superficially plausible, are, I am convinced, due to the lack of reflection and to the tendency we all have to be influenced by words or phrases, without pausing to reflect that, in their true and commonly received meaning, they are not really applicable to the thing to which they are, for the moment, applied.

Take, for instance, the word "obsolete." I doubt if there is any one word in the language that has done so much harm to the U. S. navy as this little one in its misapplied, yet common use, during a period of years with which I and many of my hearers have been contemporary. The ship built to-day, it has been freely said, will be "obsolete" ten years hence; nay, we were fortunate if we escaped the stronger yet equally positive assertion that the ship laid down to-day will be "obsolete" by the time she can be launched. What was the result of this seemingly slight and harmless exaggeration of talk? Why, simply this: That with all the valuable services and prestige of the navy during the Civil War, with the popular favor still green, with Farragut scarcely yet in his grave, everything like naval advance was stopped because of the threat of obsolescence. "Of what use," asked the unprofessional citizen, safe in an immense professional backing in the use of this word and its ideas, "of what use to build ships which are so soon to be obsolete? Let us wait until we have reached something that will not become obsolete." So we waited, with our hands and energies ironed by the little word "obsolete" until, less than ten years ago, the material of the American navy was the derision of the world and the mortification of our officers; and even now, despite the judicious and untiring efforts of recent secretaries, we have not and, for some years to come, will not have a navy commensurate with our national importance, or fitted to fulfil the fast growing sense of our proper sphere and influence in the world outside our borders. Within two years I have seen the American navy styled a phantom fleet by an English newspaper of the first rank.

How ready, all this time, the country really was to respond to an intelligent presentation of the necessities of a navy, has been shown by the liberal appropriations, and yet more by the liberal expressions of men of all parties and shades of opinion; despite this being a time, in which, until very lately, party divisions turned more on tradition than on living issues. What stopped advance was not the unwillingness of the country, but the cry of "obsolete." Yet in what other practical walk of life is advance thus conditioned? What technical calling refuses to make a step forward, because the ground it reaches to-day will be abandoned to-morrow? Who would ever dream of saying that iron rails are obsolete, in the sense that they are of no use at all, because steel rails are found to be better? And finally, before quitting the subject, what is the last, and, in my judgment, most rational, expression of foreign professional opinion concerning these so-called "obsolete" ships? Simply, yet most significantly, this: That the nation which, in the later stages of a war, be it long or short, when the newest ships have received their wear and undergone their hammering, the nation which then can put forward the largest reserve of ships of the older types, will win the struggle.

So much for "obsolete." Before passing, however, to the word upon whose erroneous application I desire chiefly to fix your attention, I want to-day to allude to an idea closely akin to "obsolete," which, though widely spread and accepted, has not, so far as I know, been formulated into a phrase with which to pass current. I allude to the view that naval history, in which is embodied the naval experience of past ages, has no present utility to us. When I was first ordered to the College, before even I had begun to develop the subjects intrusted to me, an officer, considerably my senior in rank, asked what I was going to undertake. On my naming naval history, he rejoined, "Well, you won't have much to say about that." The words, I fear, voiced a very general feeling, an impression of that vague and untested character which is ever to be deprecated when it is allowed to become a potent factor in determining action. It struck, I am free to confess, a chord in my own breast; nay, I am glad to avow that it did so, for whatever small value my own opinion may possess can lose nothing, but rather gain, by the admission that study and reflection have resulted in displacing that most powerful of resistant forces, an unintelligent

prejudice. I am, however, happy to be able to support my own conclusions, which rest upon no proofs of personal capacity for the management of modern naval fleets, by that of one of the foremost admirals now living, belonging to the largest navy in the world. The name and repute of Admiral Phipps Hornby is known, I presume, to all naval officers; certainly in his own service, where he has commanded the most modern fleets with distinction, his opinions are quoted with respect not far removed from reverence. In a letter he was kind enough to write me on a published work of mine, which embodied the results of my lectures at this College, he said: "I am glad to see that, like the German army, you base your conclusions upon the history of the profession."

I come now to the matter upon which I wish more particularly to speak; and here again I will illustrate by one of those casual conversations, which, like straws, often show more clearly than deliberate utterances how the wind of professional prejudice is blowing. I was in Washington a few months ago and, coming out of one of the clubs, I met on the door steps a couple of naval officers. We stopped to talk, and one asked me: "Do you expect a session of the College this year?" I replied that I hoped so. "Well," he said, "are you going to do anything practical?" I recognized my enemy at once in the noble word "practical," which has been dropped like an angel of light out of its proper sphere and significance, and made to do duty against its best friends, as a man's foes are often those of his own household. I endeavored to get out of the scrape, which would involve an *extempore* discussion of the true scope and meaning of the word practical, by resorting to the Socratic method, liberally practiced by the modern Irish, which would throw the burden of explanation upon my questioner. "What do you mean by practical?" I said. The reply was a little hesitating, as is apt to be the case to a categorical question, and after a moment's pause he said: "Well, torpedo-boats and launches and that sort of thing."

Of course, I knew in a general way what was coming, when I asked my question; nor did I in the least contest the application of the word practical to torpedo-boats or launches. Concerning the latter, in fact, it was a recommendation of my first report as president of the College, that such should be provided for practicing the far more delicate and difficult management of the ram in action

—a problem with which, I am bold to say, the naval mind has not begun to deal. But, while willing to concede this positive meaning, given to the word practical, I do most decidedly object to the implied negative limitation, which confines it to the tangible utilitarian results, to that which can be touched, weighed, measured, handled, and refuses to concede the honor of "practical" to those antecedent processes of thought and reflection, upon which the results of rational human effort always depend, and without which they cannot be reached—unless, indeed, by the bungling, tedious and painful method which is called "butt end foremost." It is to this view of the matter, and to the full legitimate force of the word "practical" that I wish to-day to direct your attention; for the limitation so frequently imposed on it, and so generally accepted by thoughtless prejudice, is the great stumbling block in the way of the College, just as I have tried to show that the word "obsolete" so long held the United States navy in a state of suspended animation.

In discussing the word "practical," I do not of course propose to go into its etymology, for the sake of making a barren argument as to what it ought to mean. I intend to accept it in its common significance, as familiar to us in current speech; and I propose to maintain that, in that sense, it is just as applicable to the processes of thought which precede action as it is to the action which follows thought and reflection; the only difference being that, taking the whole process of thought and action together, the thought which dictates the action is more practical, is of a higher order of practicalness than the resultant action itself. Of this the old and common proverb "Look before you leap" is a vigorous presentment. The word "practical," however, has become so warped—not in its meaning, but in its application—that the practical man is he who disdains the theoretical process of looking—that is, who will have no study, no forethought, no reflection—but simply leaps—that is, acts.

Of course, when you reach a *reductio ad absurdum*—if you do—the victim cries out: He never meant any such thing. Neither does the man who leaps without looking mean to reach the possibly uncomfortable berth in which he lands. But let it be observed, it is not man's nature to leap without looking; the irrational brute does not do that. Men leap without looking, because they have failed

to prepare, because they have neglected the previous processes of thought and reflection, and so, when the sudden call for action comes, it is "leap at all hazards;" and so, to quote Holy Writ, while they are saying "peace and safety," "sudden destruction comes upon them like travail upon a woman with child, and they cannot escape." How often have we—I speak at least to men of my own time—been told that presence of mind consists largely—for the average man mainly—in preparation of mind. When you take the deck, think what you will do in any emergency likely to arise—a man falls overboard, a collision threatens from this or that quarter, land or reef may be unexpectedly sighted. Good. But is the thought, which is simply study without books, less practical than the resultant action? Is it less practical, even if no call for action arises?

Let us, for illustration, draw upon an art which has supplied many useful analogies to describe processes of gradual development—that of the architect. Before erecting a building, be it one of simple design and unpretentious appearance, like that in which we are now seated, or be it one of the complicated and elaborate designs which decorate the cliffs of Newport—what careful study, plotting and planning goes on in the offices of the architect! What calculations to ensure convenience, to economize space, to please the eye. It is pure student's work, beyond which lie, not merely the experience of the architect, but also years of patient study, devoted to mastering the principles of his art as embodied in the experience of his predecessors. Before a brick is laid, perhaps before the sod is turned, the complete design—the future house—exists upon paper!

Is all this prior labor of the architect in his office, and all the varied study that has enabled him to perform it not "practical," and does the "practical" work begin only when the carpenter and the bricklayer put their hands to it? If you think so, gather your mechanics and your hod carriers, provide your material of bricks and mortar, and then, setting to work without your designs and calculations, rejoice in the evidence of practical efficiency you have displayed to the world!

All the world knows, gentlemen, that we are building a new navy—the process has begun, is going on, and its long continuance is an avowed purpose. We are to have a navy adequate to the sense of our needs; and that sense is bound to expand as our people ap-

preciate more and more, and as they are beginning to realize more and more, that a country's power and influence must depend upon her hold upon regions without her own borders, and to which the sea leads. The influence of the little British islands gives a lesson our people will surely learn. Well, when we get our navy, what are we going to do with it? Shall we, like the careless officer-of-the-deck, wait for the emergency to arise? If we do, we shall pretty surely leap without much looking. Or do you think that when the time of war comes you will find a *vade mecum*, a handy pocket manual, the result of other men's labors, which will tell you just what to do; much like one of those old seamanship problems: Riding to a single anchor and ebb tide, with the wind on the starboard bow and a shoal on the port quarter, get underway and stand out to sea. A remark to that effect was made by an officer, a commander now afloat, who I think is regarded by all as one of our most intelligent, as he certainly is one of our most advanced men. "I thought," he said, in discussing some naval problems, of the kind with which the College proposes to grapple, "that, the case arising, I could turn to some work where the dispositions of a fleet, of a convoy, and other various questions connected with maritime expeditions would be treated and their solution stated; but I find there is none, and I myself do not know." At present the matter is perhaps of little consequence; but will it not be unfortunate for the responsible officers to be in like plight, when the call for action arises?

It is a singular comment upon the line in which naval thought has long been running, that the reproach to the French navy, though it was then a very accomplished service, near 100 years ago, by one of its most thoughtful members, is equally applicable, perhaps even more applicable to the naval profession of all countries in our own day. "The art of war," said the writer, "is carried to a great degree of perfection on land, but it is far from being so at sea. It is the object of all naval tactics, but it is scarcely known among us except as a tradition. Many authors have written on the subject of naval tactics, but they have confined themselves to the manner of forming orders or passing from one order to another. They have entirely neglected to establish the principles for regulating conduct in the face of an enemy, for attacking or refusing action, for pursuit or retreat, according to position or according to the relative strength of the opposing forces."

This is painfully the case now. Not only during the time I was actually resident here, but in the four years that have since then elapsed, I have made a practice of sending for the catalogues of the leading military and naval booksellers, at home and abroad, and carefully scanning their lists. Whatever could be found bearing in any way on the art of naval war I have had ordered for the College library; with the result that a single one of the short book shelves you can see downstairs, contains all that we have to show on the subject of naval tactics; and of that space nearly one-half is occupied with elaborate treatises upon the tactics of sailing ships, from Paul Hoste to Chopart. Of the remainder, none can be quoted as an authority; and it may be questioned if any rises to the dignity of a systematic, well-digested system. They are simple, short essays, more or less suggestive; but that they possess no great weight is evident from the fact that the authors' names suggest nothing to the hearer.

The significance of this fact, however, does not lie in the mere absence of treatises. Did such exist, had we the *vade mecums*, the pocket manuals, with their rules and standards, the work of some one or two masters in the art, their usefulness to the profession would be very doubtful if they did not provoke others to search for themselves—to devote time and thought to mastering the facts, and the principles upon which the supposed masters had based their own conclusions. War cannot be made a rule of thumb; and any attempt to make it so will result in disaster, grave in proportion to the gravity with which the issues of war are ever clothed.

No, the lamentable fact indicated by this meagre result is that the professional mind is not busying itself with the considerations and principles bearing upon the Conduct, or Art, of War. There is no demand, and therefore there is no supply. There is little or no interest, and consequently there are no results. In what other department of modern life is lively professional interest unaccompanied in this age by publication? In what other is there found a total neglect of the great medium of the press, by which men communicate their thoughts to others, and at the same time an active gathering and dissemination of results? Nay, in other branches of our own profession—in gun construction, in ship construction, in engine building, in navigation—there are treatises in plenty, indicating that interest is there, that there is life; but when we come

to the waging of war there is silence, because there we meet sleep, if not death. It was said to me by some one: "If you want to attract officers to the College, give them something that will help them pass their next examination." But the test of war, when it comes, will be found a more searching trial of what is in a man than the verdict of several amiable gentlemen, disposed to give the benefit of every doubt. Then you will encounter men straining every faculty and every means to injure you. Shall we then, who prepare so anxiously for an examination, view as a "practical" proceeding, worthy of "practical" men, to postpone to the very moment of imperative action the consideration of *how* to act, *how* to do our fighting, either in the broader domain of strategy, or in the more limited field of tactics, whether of the single ship or of the fleet? Navies exist for war; and if so, the question presses for an answer: "Is this neglect to master the experience of the past, to elicit, formulate and absorb its principles, is it practical?" Is it "practical" to wait till the squall strikes you before shortening sail? If the object and aim of the College is to promote such study, to facilitate such results, to foster and disseminate such ideas, can it be reproached that its purpose is not "practical," even though its methods be at first tentative and its results imperfect?

The word "practical" has suffered and been debased by a misapprehension of that other word "theoretical," to which it is accurately and logically opposed. Theory is properly defined as a scheme of things which *terminates in speculation, or contemplation*, without a view to practice. The idea was amusingly expressed in the toast, said to have been drunk at a meeting of mathematicians, "Eternal perdition to the man who would degrade pure mathematics by applying it to any useful purpose." The word "theoretical" is, therefore, rightly and legitimately applied only to mental processes that end in themselves, that have no result in action; but it has, by a natural, yet most unfortunate, confusion of thought, come to be applied to all mental processes whatsoever, whether fruitful or not, and has transferred its stigma to them, while "practical" has walked off with all the honors of a utilitarian age.

If therefore the line of thought, study and reflection, which the War College seeks to promote, is justly liable to the reproach that it leads to no useful end, can result in no effective action, it falls justly under the condemnation of not being "practical." But it

must be frankly and fearlessly said that the man who is prepared to apply this stigma to the line of the College effort must also be prepared to class as not "practical" men like Napoleon, like his distinguished opponent, the Austrian Archduke Charles, and like Jomini, the profuse writer on military art and military history, whose works, if somewhat supplanted by newer digests, have lost little or none of their prestige as a profound study and exposition of the principles of warfare.

Jomini was not merely a military theorist, who saw war from the outside; he was a distinguished and thoughtful soldier, in the prime of life during the Napoleonic wars, and of a contemporary reputation such that, when he deserted the cause of the emperor, he was taken at once into a high position as a confidential adviser of the allied sovereigns. Yet what does he say of strategy? Strategy is to him the queen of military sciences; it underlies the fortunes of every campaign. As in a building, which, however fair and beautiful the superstructure, is radically marred and imperfect if the foundation be insecure—so, if the strategy be wrong, the skill of the general on the battlefield, the valor of the soldier, the brilliancy of victory, however otherwise decisive, fail of their effect. Yet how does he define strategy, whose effects, if thus far-reaching, must surely be esteemed "practical?" "Strategy," he said, "is the art of making war upon the map. It precedes the operations of the campaign, the clash of arms on the field. It is done in the cabinet, it is the work of the student, with his dividers in his hand and his information lying beside him." It originates, in other words, in a mental process, but it does not end there, therefore it is practical.

Most of us have heard an anecdote of the great Napoleon, which is nevertheless so apt to my purpose that I must risk the repetition. Having had no time to verify my reference, I must quote from memory, but of substantial accuracy I am sure. A few weeks before one of his early and most decisive campaigns, his secretary, Bourrienne, entered the office and found the general, as he then was, stretched on the floor with a large map before him. Scattered over the map, in what to Bourrienne was confusion, were a number of red and black pins. After a short silence the secretary, who was an old friend of school days, asked him what it all meant. The general laughed goodnaturedly, called him a fool, and said: "This set of

pins represents the Austrians and this the French. On such a day I shall leave Paris. My troops will then be in such positions. On a certain day, naming it, I shall be here, pointing, and my troops will have moved there. At such a time I shall cross the mountains, a few days later my army will be here, the Austrians will have done thus and so; and at a certain date I will beat them here," placing a pin. Bourrienne said nothing, perhaps he may have thought the matter not "practical;" but a few weeks later, after the battle (Marengo, I think) had been fought, he was seated by the general's side in his military traveling carriage. The programme had been carried out, and he recalled the incident to Bonaparte's mind. The latter himself smiled at the singular accuracy of his predictions in the particular instance.

The question I would like to pose will, in the light of such an incident, receive of course but one answer. Was the work the general was engaged on in his private office, this work of a student, was it "practical?" Or can it by any reasonable method be so divorced from what followed, that the word "practical" only applies farther on. Did he only begin to be practical when he got into his carriage to drive from the Tuileries, or did the practical begin when he joined the army, or when the first gun of the campaign was fired? Or, on the other hand, if he had passed that time, given to studying the campaign, in arranging for a new development of the material of war, and so gone with his plans undeveloped, would he not have done a thing very far from "practical?"

But we must push our inquiry a little farther back to get the full significance of Bourrienne's story. Whence came the facility and precision with which Bonaparte planned the great campaign of Marengo? Partly, unquestionably, from a native genius rarely paralleled; partly, but not by any means wholly. Hear his own prescription: "If any man will be a great general, let him study." Study what? "Study history. Study the campaigns of the great generals —Alexander, Hannibal, Cæsar," (who never smelt gunpowder, nor dreamed of ironclads) "as well as those of Turenne, Frederick and myself, Napoleon." Had Bonaparte entered his cabinet to plan the campaign of Marengo, with no other preparation than his genius, without the mental equipment and the ripened experience that came from knowledge of the past, acquired by study, he would have come unprepared. Were, then, his previous study

and reflection, for which the time of action had not come, were they not "practical," because they did not result in immediate action? Would they even have been not "practical" had the time for action never come to him?

As the wise man said, "There is a time for everything under the sun," and the time for one thing cannot be used as the time for another. That there is time for action, all concede; few consider duly that there is also a time for preparation. To use the time of preparation for preparation, whatever the method, is practical; to postpone preparation to the time for action is not practical. Our new navy is preparing now; it can scarcely be said, as regards its material, to be yet ready. The day of grace is still with us—or with those who shall be the future captains and admirals. There is time yet for study; there is time to imbibe the experience of the past, to become imbued, steeped in the eternal principles of war, by the study of its history and of the maxims of its masters. But the time of preparation will pass—some day the time of action will come. Can an admiral sit down and re-enforce his intellectual grasp of the problem before him by a study of history, which is simply a study of past experience? Not so; the time of action is upon him, and he must trust to his horse sense. The mere administration and correspondence of a fleet leaves all too little time. Even with captains, the administration of a single ship of the modern type makes demands that leave little time for the preparation of study. Farragut bewailed this burden; and Napoleon himself admitted, in his later days, that he never did better work than in his first campaign, to which he brought preparation indeed, but the preparation rather of the student than that which is commonly called "practical." The explanation he gave was this: That in the first, though inexperienced, he had more time for thought, more time maturely to consider and apply the knowledge he possessed, and which he then owed, not to what is called "practical work," but to the habits of study. Ten years later he had had much more practice, but he did not excel the early work, for which his chief preparation lay in a course of action what is now commonly damned as "theoretical." At the later day the burden of administration lay too heavy, but he had so used his time of preparation that, though he did not improve, he was able to bear it.

Bonapartes, doubtless, are rare—for which very reason, perhaps, that which he found necessary cannot be inexpedient for lesser men —and even below the rank of great genius few can expect to attain the highest degree of excellence; but we all look forward to command, in one way or another, and command in our profession means liability to be called on for action, of a rare and exceptional type, for which preparation by previous action may not, probably will not, have been afforded. To each and all of us that test may come, and according to our previous preparation it may be opportunity, or it may prove to be ruin. Let us not deceive ourselves by the unquestionable excellence that our service has attained in the common and peaceful line of its daily duties. That it has so done has been due to two causes: first, the admirable preparatory study of the Naval Academy; second, the opportunity for putting in practice what is there learned. But neither in study previous, nor in practice, is any provision being made for the stern test of war; nor do the occupations of peace provide other than a part, and that the smaller part, of the equipment there needed. The College has been founded with a view to supply the preparation, by antecedent study, and by formulation of the principles and methods by which war may be carried on to the best advantage. That this purpose is "practical," seems scarcely open to question. That success may be attained only after many mistakes and long effort, is merely to say that it shares the lot of all human undertakings.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

WARSHIPS AND NAVAL WARFARE.

By Ch. Chabaud-Arnault, French Naval Commander, Retired.

Translated, by permission, from the *Revista Maritima Brazileira.*

By Professor Jules Leroux, U. S. Naval Academy.

For twenty-five or thirty years—since the War of the Rebellion in the United States and the war between Brazil and Paraguay—up to the present date, the warship and naval warfare have made vain efforts to pursue their true courses without deviation, and follow, in a rational manner, the fundamental principles that must prevail in the construction of the different types of the former and in the general direction of the operations of the latter. At the present time those principles finally appear to be emerging from the obscurity that enveloped them; and, while disclaiming the rash pretense of fixing them here upon a firm and complete basis, we may at least try to sketch their main outlines. During the last quarter of a century we have constantly seen arrayed against one another the champions of enormous armor-clads and those of diminutive torpedo-boats; the advocates of the 100-ton gun and of small ordnance; the partisans of squadron operations and of individual cruisers; each side being most conclusive in its conceits and unwilling to consider but one object, where inevitably several must always exist. Hence, those men who persisted in seeking the truth between the extreme ideas of theorists came to be looked upon with distrust and were sneered at. But the hour of triumph has come for the latter, and their wisdom is finally to be rewarded; at least we trust so.

In order to thoroughly understand the change of ideas that is taking place in regard to this matter, we must, first of all, guard

against mixing up the two intimately connected yet distinct elements composing the art of war, *viz.*, tactics and strategy.

At sea as well as on land, tactics is the art of using to the best advantage on the battle-field the forces one has under his command. There alone the direct implements of attack and defense—weapons—find their use; guns and armor, rams and double bottoms, torpedoes and protective nets are nowadays the principal weapons, offensive as well as defensive, of a man-of-war.

At sea as well as on land, strategy is the art of "determining the decisive points of the seat of war, and the lines or general routes along which armies must move in order to reach them." And strategy as well as tactics has not only its weapons, but its own appropriate means; the principal of these for warships being speed, seaworthiness, extent of radius of action, habitability (suitable living accommodations); in one word, what we shall call nautical qualities, as distinct from purely military qualities, which tactics alone can utilize.

Now, if the latter, by being transformed in sympathy with the weapons, make necessary great changes in tactics, the former, *i. e.*, nautical qualities, constitute, on the contrary, the immutable bases of naval strategy, whose fundamental principles consequently cannot vary. At all times, indeed, in the past as well as in the present, superiority of speed, the ability to keep the sea longer and under better conditions than the adversary, while giving better comforts to the crew, have been and still are the essential qualities of the large battle-ship, which qualities enable it to reach in the minimum space of time the "decisive points of the seat of war" and to sail with a minimum loss of efficiency over the "general routes along which it must move to reach them;" in other words, enable it to accomplish entirely the object of strategy.

We therefore repeat, if naval tactics must change with the armaments and composition of fleets, "naval strategy is immutable, at least in its principal lines."

It is because they forgot or neglected this great and fundamental principle, that many naval theorists strayed in the pursuit of an unrealizable object, and it is for this reason that they gave the *rôle* of the torpedo and torpedo-boat an exaggerated importance. They wanted to sacrifice to speed nearly all the other qualities of a fighting ship, assuming that on board the craft of their dream men must be

made absolutely subordinate to machines; and, on the other hand, unwilling to take into the least account the teachings of history as well as the inalienable rights of humanity, they have taken the Quixotic notion of completely upsetting the object of naval strategy, and have inaugurated a system of warfare, which, if put into practice by commanders, would revive the worst epochs of barbarity.

We shall try to prove that these are just so many errors, inconsistent with certain necessities that have always been, and always will be, imposed by a rational prosecution of naval warfare.

As soon as the first high-speed torpedo-boat was designed and built, the majority of naval officers recognized that a new and terrible weapon of war had made its appearance. Still, there were some skeptics; but their scoffings were soon met by the evidence of the very important *rôles* filled by half-a-dozen Russian torpedo-boats during the naval war carried on on the Danube in the years 1877–1878. As an offset there sprang up at that time a party of officers who rested a whole system of naval warfare upon the almost exclusive use of torpedo-boats, backed only by a few gunboats proportionately small and fast, and also by a very limited number of cruisers.

Great speed, number and invisibility (relative only, of course) were the three conditions all naval men have considered from the beginning, and, indeed, should still consider, as indispensable to the success of a torpedo-boat. Now, of the above three conditions the last two involve necessarily a reduction of size, for a fixed amount of money will only buy a large number of boats on the express condition that the cost of each one of them shall be moderate, entailing as a consequence a reduced size of hull; on the other hand, the smaller that hull be, the less visible to the R. F. cannon of the enemy. It can then be affirmed that the chances of success of such a boat will diminish in proportion as its size will increase, for it is at the expense of its purely military or tactical qualities that it is sought to increase its nautical or strategic qualities: endurance—in other words, protracted maintenance of speed—seaworthiness, habitability, extended radius of action, which are all indispensable to enable it to follow away from the coasts large warships, whether they be armored battle-ships or cruisers.

To the unrealizable desire to build a war-craft fulfilling those contradictory conditions the seagoing torpedo-boat owes its creation. At the present hour the latter consists of a light-built hull

of from 100 to 150 tons, bigger than a boat and smaller than a ship, generally provided with three or four torpedo-tubes and about the same number of R. F. cannon, capable, under favorable sea conditions, of proving a real help to an armored vessel, though rather as a torpedo-catcher than in any other capacity; but losing at the same time both fighting and nautical qualities the moment the sea becomes the least rough. Then the firing of the torpedoes becomes uncertain, when not utterly impossible, its speed falls much below the average, and the strain becomes excessive for men and machinery, and in any event its radius of action, owing to its limited supplies, is far more restricted than that of a larger craft.

As to the vessels—real ones these, owing to their dimensions—called torpedo-scouts, despatch torpedo-boats and torpedo-cruisers, we vainly ask, why is this qualifying word "torpedo" added to the names? In reality, no essential difference exists between them and those that are simply designated by the names of scouts, despatch boats, and cruisers, without adjuncts. Every one in its corresponding class is provided with very nearly the same number of torpedo-tubes and small rapid-firing batteries.

The preceding considerations clearly show that besides boats, simple fast boats of 20 to 70 tons, basing their offensive as well as their defensive power on their speed, number and invisibility, there can be no torpedo-boats properly so called. The self-sustaining torpedoer, as well as the small gunboat (bateau canonnier), fitted to fulfil all sorts of tasks, and to fight on the high seas as well as near the coasts, is nothing but a chimera born of the exaggeration of an idea, correct in itself, and fraught with good results. The moment that the "boat" becomes transformed into a vessel through the necessary increase of its dimensions, in order to extend its radius of action and sail away from the coast, it renounces two of its three essential qualities, *viz.*, number and invisibility; and it, the scorner of armor, is constrained to put on armor, in order to protect its vitals, at least, against the effects of quick-firing cannon by increasing the thickness of part of its hull. At the same time its deck is armed with a secondary battery, and its stem with a ram. Here we have no longer a torpedo-boat, but any craft whatever, be it scout, despatch boat or cruiser.

The principle of the division of labor has also been invoked, with as little success as a plea for the substitution of the torpedo-boat and

fast gunboat for the larger vessels of the actual fleets. If we were to believe in certain theories, the inevitable application of that principle would lead to the building of hulls of small dimensions, all of the same type, each provided with one single weapon—gun, automobile torpedo or spar-torpedo. Assembling then the three kinds of boats thus obtained, a fighting unit would be constituted, sufficient for every task. It would be impossible to emit a more radically absurd idea. As the Secretary of the United States Navy has expressed it, in a sentence as remarkable for its conciseness as for its clearness, if it is desired to put the principles of the division of labor into sound practice in this case, it becomes necessary, on the contrary, to "build ships of different types for different objects, each one as perfect is it is possible to make it—battle-ships, cruisers and coast defense vessels;" and, as the galley of the sixteenth and seventeenth centuries carried at the same time guns, a ram and soldiers, ready to invade the deck of the adversary, there is no plausible reason why the modern man-of-war should not, size permitting, be provided with all the weapons that may be useful to it. The consequence is that, far from the armored battleship being given its death-blow by the diminutive torpedo-boat, as boastfully predicted, that sea-monster is still relied upon as indispensable in forming the nucleus of military fleets; and we have beheld it increasing progressively in size, as well as the cruiser and, indeed, the torpedo-boat itself. It is evident that we shall have to come to a stop in this line; finally conquered, not by the torpedo-boat, but by the cannon-ball loaded with an explosive of irresistible power, the real armor is very likely to disappear in the near future. But whilst war will be waged on the high seas, the requirements of strategy will make it imperious to build ships of different types for different purposes; some having the proportions of real ships and provided with all the suitable weapons, because intended, in case of need, to sail to any part of the globe, and to operate far from the coasts; others, on the contrary, deriving their principal power, for both offense and defense at the same time, from their number and relative invisibility, because their main, in fact their only, task will be to protect those very coasts.

Some writers on naval subjects flatter themselves that they have discovered an entirely new principle by proclaiming that superiority of speed is one of the essential factors in a successful war

whether it is a question of squadron, or cruiser acting alone. Going still further, some aver that speed constitutes a new weapon, superior to all others, as well as a nautical quality, to which should be sacrificed, in great part, those others that have been, up to the present, considered as indispensable to a man-of-war. Now it can be easily demonstrated that, at all times, speed has constituted at sea the first perhaps of all strategic advantages, and on the other hand, experience has already shown that it would be ill-advised to regard as of secondary importance certain qualities of the fighting ship, some nautical, others military—less brilliant on the outside, but more solid than actual speed.

History warrants us in basing the first of these two propositions upon irrefutable arguments. Without going too far back in the past, it will suffice to study carefully the relation of the cruises of the Dorias, Draguts and Barbarossas, to become convinced that those famous captains owed their success to the fleetness of their galleys as much, at least, as to their personal skill and the valor of their companions in arms. At epochs nearer our times, during the wars of 1778–1783, and those of 1793–1805, the English held in check or beat completely the French and Spanish sailors, thanks only to the superior speed of their squadrons. These are facts set off clear as daylight by the close study of those memorable struggles. Thus, in the days of sailing ships as well as in those of galleys, speed at sea has been considered one of the prime elements of success, and it is in virtue of an imprescriptible strategic law as old as the first naval battle, that things are not different nowadays.

Unfortunately, it happened that with their minds stimulated, constrained, so to speak, by the exaggerations of a so-called new principle, ship builders only obtained the maximum of speed demanded of them at the expense of two other essential and kindred qualities, *viz.*, staunchness of hull and endurance of engine; that is, capacity of the latter of working for long periods at a rapid rate, without strain and unusual risk of accidents even in bad weather. It is not, indeed, necessary to be a sailor or an engineer to understand that a very light built hull, driven forward by a powerful motor, will bend and twist at every moment under the resistless action of the waves through which it will rush at a furious speed; and as a consequence the various organs of its engine will

become disjointed and sustain frictions and shocks that are bound to result in some serious mishap.

However, as long as the idea was only to build simple torpedo-boats of very high speed for immediate defense of roads and harbors, it was natural to consider only speed. The tasks of these crafts being intended to remain always local and performed within narrow limits and in usually calm waters, their need of the strategic qualities of large battleships was only of secondary consideration; with them superiority of speed itself is only a purely tactical quality; if indispensable to them on the battlefield, it is hardly so anywhere else, and then only for a very short while. There was, therefore, no inconvenience in sacrificing endurance to it.

But it is just the reverse, when we refer to a vessel intended to fight on the high seas, whose performances on the battlefield may be preceded by strategic manœuvres of rapid execution over a wide area. In such case, we say it over and over again, great sea-worthiness, habitability and endurance must go hand in hand with speed, the latter making a sacrifice if necessary. This fact has been abundantly demonstrated during the grand manœuvres executed within the last three or four years by the fleets of various maritime powers. In this connection experience is conclusive, and there is no need of waiting for the confirmation of new and real war operations.

After all, speed for large battleships is a quality far more strategic than tactical, for it is generally admitted that, with the exception of very short spaces of time, armored vessels in action will not move at their highest speed. In such circumstances, their quick turning power, their manœuvring qualities, will be of more importance than superior speed, a quality that is so precious, on the contrary, when associated with endurance, in all sorts of strategic operations. Hence it was wrong, in our opinion, to number speed among the properly so-called weapons of a man-of-war—gun, ram and torpedo; it was, above all, a mistake to write that among the latter, speed must always occupy the first rank.

We will sum up, then, by saying (1) it is a mistake to think that superiority of speed had less importance for sailing vessels than it has for steamships; (2) to that superiority, desirable as it may be, we must avoid sacrificing the others, whether they be of a nautical or fighting order.

Everybody is now familiar with the strange sights that meet him when he penetrates into the interior of a large man-of-war. This steel monster, so ponderous and strong and so simple in construction, looking at it from the outside, is, on the other hand, set in motion, steered and utilized in action by such a large number of complicated and delicate organs (we have reference here to a large armored battleship), that as many as 84 subsidiary engines have been counted on board. This is because not only the ship itself, but the guns, torpedoes, lighting, everything, is worked by steam or electricity. The direct hand of man that formerly worked helm, gun, oar, or sail, has been, in most cases, replaced by purely mechanical power, and for this reason many a naval writer predicts that "future battleships will be real monsters, whose brains will be their captains, and their nerves the wire connections," and the same writers boldly proclaim that henceforth a nation will rely for success in naval combats, far more on the perfection of her naval art than on the valor of the *personnel* of her fleet. This is, indeed, rating very low the moral qualities of man in order to extol his intellectual ones. We think, on the contrary, and every-day experience confirms our belief, that the more perfect the weapons of war at sea, the more intelligence, coolness, presence of mind and decision in the midst of the most terrible dangers—true valor, in a word—will be required of those that will handle them. Have we not, every one of us, heard it stated a hundred times that owing to the furious rush with which two hostile squadrons will meet, mingle in confused mass and dash against one another, the task of the captain will become more and more arduous? On the other hand, suppose that for one single instant any officer, engineer, chief gunner or torpedo artificer should neglect his duty, or be guilty of the least oversight, would not the ship or boat on which he serves be doomed on account of that single slip? In former times, when the sail or oar was the only propelling power of the warship, one had time to recover and look about on the battlefield, to repair the mischief done, to offset the effects of a false manœuvre or of a badly delivered broadside, because the motions and evolutions of ships were relatively very slow, and also because their means of destruction were not so sudden. It is quite different nowadays; the longest evolution lasts but a few minutes, the first blow of a ram, the first shock of a torpedo, the first well delivered broadside

the staunch ship receives gives it its death blow, or at any rate cripples it. We have a right, then, to affirm that not only the captain's gallantry, but that of every man acting under his command will more than ever before have an overwhelming influence upon the final results of naval contests. Nothing under such circumstances can make up for man's moral strength, based, not upon a professional knowledge more or less developed, but upon a truly patriotic education that will imbue each individual character with all the energy, perseverance and devotion of which it is capable. Even setting aside this primordial consideration, on the ocean still more than on land, knowledge is inadequate to insure success; love for the profession, and great familiarity with things pertaining to the sea are necessary. Will not every one suppose, for instance, that when the ship is tossed about by the waves the fireman, feeding his furnace away down in a hole laden with the offensive smell of burnt oil and grease, will require a far steadier stomach than the sailor aloft, who while taking in a sail at least breathes a pure vivifying air? Will not the torpedo artificer, shut up within the cramped and noisome shell of a boat, rolling fearfully in the least swell of the sea, have to be possessed of better sea-legs than the gunner, who formerly pointed his piece on the roomy deck of the big, solid line-of-battle ships?

If, therefore, thoroughly drilled officers and men, each in his own specialty, are necessary to man modern battleships, it is no less necessary that the entire *personnel* should possess undaunted valor and a true naval vocation.

All that we have said heretofore we will now try to sum up as follows: A ship's weapons—that is, its direct means of attack and defense—having completely changed, we will admit with everybody that the same is true of naval tactics, and in this respect the past cannot teach us any useful lesson. But, it being impossible to free naval warfare from the exigencies of a capricious and terrible element, or, after all, modify its principal objects, the nautical or strategic qualities indispensable to every type of ship in order that it may accomplish its task satisfactorily, must, of necessity, remain about what they were before. For the same reasons, if it has been found necessary to give the officers and men of the various specialties an education entirely different from that of their predecessors, we should prize in them as in the latter first of all moral qualities and sea experience.

We have just said that *naval warfare cannot, after all, alter its prime objects*; let us now try and prove it briefly.

The reverse theory has never been and never can be upheld, except through exaggeration of the new means that science has placed in the hands of attack, and refusal in most cases to take into account the analogous resources which the same science equally insures to the defense. Thus it has been claimed by some that hereafter the blockade of harbors and coasts, and the transportation and landing of troops, will be well-nigh impossible, owing to the high speed and little visibility of torpedo-boats and small cruisers, as well as the multiplicity and suddenness of their attacks. To be sure, if a squadron composed exclusively of armored ships attempted to blockade a flotilla of torpedo-boats they would not only fail in the attempt, but expose themselves to a terrible disaster; it would be equally powerless in protecting the safe passage, or the anchoring in full view of a hostile coast, of a fleet of transports possessing, like itself, only a moderate speed. But add to or substitute for your armored ships torpedo-catchers and small cruisers as numerous as the boats of the enemy, use them to blockade the latter or to convoy swift-sailing ocean steamers loaded with troops, and at once harbor and coast blockade, transportation and landing of troops, become very feasible operations. And as, in order either to blockade the enemy's coasts or safely transport troops on board vessels, one must be master of the sea, squadrons composed of large and powerful battleships will continue to be indispensable to all maritime nations desirous of retaining the power of performing those operations.

But it is alleged that in the presence of the millions of men composing the armies of the great powers, owing specially to the means of rapidly concentrating these formidable masses, no country would think of landing thirty, forty or sixty thousand men at any point, even the most favorable, of the enemy's territory. There is some truth in that assertion; only those who make it an insurmountable obstacle to the landing of troops forget that these landings are, in most cases, effected on the territory of an ally, or on a coast partly in the power of the party undertaking them. Such, for instance, was the case with Wellington's soldiers when they set foot upon the Iberian peninsula in order to aid its people to expel the French from its soil, and later on, when they invaded Belgium

to crush at Waterloo, in concert with the Dutch and Prussians, Napoleon's last army. It was also on a friendly coast that the French troops were landed in 1859, who were carried to Genoa and Leghorn to protect Piedmont and Tuscany against the aggression of the Austrians. Some years ago, during the war of Secession and that between Brazil and Paraguay, the troops that ascended certain rivers upon federal vessels or Brazilian transports, landed on portions of territory already, wholly or partially, conquered by the respective armies of the two nations. There is no reason why the same should not take place in the future.

In order to justify still further the idea of replacing squadrons composed of large battleships by flotillas of boats and very small craft, it has been alleged by some writers that henceforth "it will be idle and absurd for a fleet to attack coast fortifications, because the object of the naval wars of the future will be not so much the ruin of the naval power of the adversary as that of his commercial power, his wealth." Nothing can be more false than that theory, and more in contradiction with the unavoidable necessities of a great struggle, waged at the same time on both land and sea. In the war of Secession, could sea or river strongholds like Vicksburg, Mobile, or Wilmington, have been captured by the land troops attacking them, without the powerful co-operation of the federal vessels? Did not the Brazilian armorclads contribute their aid in the most efficient manner to the soldiers of that same nation in the taking of Curupaity, Humaytá and Angostura? If to-morrow war broke out (which God forbid!) between France and Italy, would not the troops of the first in order to take Genoa, or those of the second to capture Toulon, need the efficacious aid of a certain number of armored battleships?

It is not necessary to pursue further the demonstration of a truth that forces itself upon the minds most prejudiced against it, to wit: that the fundamental principles of naval strategy have remained and are bound to remain unchanged, because the prime objects of naval wars have not changed, and cannot change.

Let us now study from another point of view the question already treated in previous paragraphs. Those writers who, setting aside the teachings of common sense as well as of history, proclaim that naval warfare must henceforth be a purely "industrial" one, having, consequently, but two objects—destruction of the

enemy's merchant vessels, and ruin of its commercial emporiums—wish to establish an entirely new system of naval strategy. To be efficient, they say, war must be merciless, and torpedo-boats, which, in their opinion, are the principal weapons in privateering operations, must await the cover of night to send to the bottom the enemy's ocean steamers they will meet, with their cargoes, their crews and passengers, women and children included, without troubling themselves about ascertaining the nationality of those ships in a formal and legal manner. In the same way gunboats, the best adapted craft for coast warfare, will shell and burn unexpectedly open cities of the seaboard, without bothering about notifying, even an hour beforehand, the authorities of these populous cities or the foreign consuls residing in them, of their intentions. These theorists affirm that, conducted in that atrocious manner, an industrial naval war would soon bring to terms the nation that would happen to be the victim.

Let us first consider commerce destroying operations. In the mind of the unprejudiced reader who will carefully consult the history of the last three centuries, this truth will appear: Never has the ruin of the carrying trade of the enemy had any decisive influence upon the general results of any struggle, or upon the conditions of a subsequent peace. Every time, for instance, that the fleets of France and Spain were powerless against those of England, the first two waged a successful war of privateering against the latter. Did they succeed in conquering their rival? Not a particle! Would the case be different if to-morrow hostilities were renewed between the same countries? We will answer No! because, although the writers in the case do not mention the fact, confronting the new and powerful means of attack we find corresponding resources for defense. Thus those writers affirm that numerous French torpedo-boats scattered all over the Channel could destroy every merchant vessel that dared to venture in it. A palpable mistake, for the naval manœuvres of the last few years have demonstrated beyond a doubt that a flotilla of torpedo-catchers would promptly put a stop to the operations of the assailants. In the same way, to the French cruisers distributed over the ocean the English would oppose a greater number of cruisers that would capture them one after another. Besides, do not ocean merchant steamers possess an equal, and even a superior speed, that would

enable them to escape capture? Cannot, on the other hand, small divisions of cruisers protect, as did the frigates of old, flotillas of merchantmen? And again, do not modern merchant steamers possess more freedom than the old in changing their routes from harbor to harbor, and in selecting their ports of landing, so as to circumvent the vigilance of the cruisers and torpedo-boats of the adversary?

It has then been rightly asserted that commerce destroying operations alone will be powerless in coercing a nation struggling for its existence.

Will the second object of the exclusive partisans of "industrial warfare," that is, the ruin of the commercial marts of the adversary, lead to better results? Certainly not, in spite of the enormous range of the modern gun and the terrible effects of the new projectiles charged with powerful explosives.

In the first place, here again the defense possesses means that increase parallel with those of attack. In the daytime it can oppose guns equally powerful, and generally more numerous, and at night its dreaded flotilla of torpedo-boats; before long, no doubt, it will add the submarine torpedo-boat, which in daytime will be a tremendous auxiliary to its batteries.

But let us suppose that the defense is decidedly inferior to the attack. In case of a war between France and Italy, would the laying in ashes of Leghorn, Genoa, Palermo, or Naples put the whole of the latter country at the mercy of the first? No, a thousand times, no; no more than the ruin of Bordeaux, Havre, Cette, or Marseilles would force France to lay down her arms in the struggle for her existence. For, let it be remembered, a merciless war has this peculiarity; it inspires the weak with courage, a desperate courage, and not only courage, but a savage hatred and a thirst for revenge, from which several future generations will suffer. This is a truth that shines forth on every page of history.

Unfortunately, when the human mind swerves from the true path it will not stop, and we see writers (fortunately the exception, we must confess) proclaiming that war means the total ruin of the enemy; "neither age, sex, nor prisoners must be spared." The complete wiping out of existence of the adversary must be on either side the final object. Truly, such a theory is not worth discussing; if put into practice it would move humanity from the highest state

of civilization back to one of barbarity, it would be the negation of all progress, naval and social, and, far from having as a result the end of all wars, as perhaps imagined by some visionaries, it would establish in the world a general and perpetual state of truly atrocious hostilities by fostering bloody customs and savage hatreds.

In order to sum up our opinion in regard to this momentous question of warships and naval warfare, a complete study of which would require volumes, we will set down the following: If the warship with its various types, each essential to the purpose for which it was built, is entirely different nowadays from what it was; if, as an inevitable consequence of this fact, tactics and naval combat have had, one to reform all its rules, the other to change all its means; on the other hand, the prime objects of naval strategy necessarily remain unchanged—engagements with hostile squadrons to decide the supremacy of the sea; coast and harbor blockades; co-operation with land forces in transporting troops or in attacking sea fortifications. And if we earnestly desire that certain objects of this strategy, at all times secondary ones at most, just as they are now, should disappear with common accord from the programme forced upon past, present and future squadrons from the very nature of things, it is not hard to surmise that we have reference only to the capture of merchant vessels and bombardment of the purely commercial seaports of the enemy. Were it otherwise it would be necessary to give up in despair the progress of human reason, justice and charity.

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THE VAN DUZER-MASON ELECTRIC STEERING GEAR.

By Ensign Lewis S. Van Duzer, U. S. N.

This apparatus may be fitted either as a steering gear or as a device for controlling a steam engine or other form of motor. As a steering gear it is exceedingly simple. Two reversible motors are placed at opposite ends of a worm shaft. Traveling on the shaft is a nut, bearing a sleeve which slides on the tiller to allow of rectilinear movement of the nut. The power of the motors varies with the size of the rudder, the mamimum anticipated pressure against it, and the desired speed of operations (*i. e.*, of moving the helm). Two motors are used instead of one as a measure of precaution. In case of the break-down of one, the other would be able to move the helm at a reduced speed. If the additional expense is not objected to, the motors should each be of size sufficient to develop the full necessary power, so that only one need be connected up at a time, the other being held in reserve. The carbon brushes of the reserve motor are drawn back, the current cut off and the armature allowed to revolve freely with the shaft.

When used as a controlling device for directing the movements of a Williamson or other form of steering engine—steam, hydraulic or pneumatic—the motors, much smaller of course, are arranged on a worm shaft as before described. The worm actuates a gear-wheel on the valve, or differential, shaft. The proper speed of turning the shaft is obtained by proportioning the gear-wheel and pitch of the worm to the speed of the motor. It is further controlled by an automatic switch, actuated by the engine itself, and throwing in or cutting out resistance in the operating circuit.

The wiring and the steering box (Figs. 1 and 2) are alike for both electric steerer and electric controller, except when these engines are not fitted with a "differential." In such cases the method of wiring and the connections vary according to circumstances. Nearly all cases require slightly different leads and slightly different treatment, but the general plan is the same. The wiring in all cases consists of three circuits: the main or operating circuit; the contacting, switching or reversing circuit; and the cut-out circuit. The operating circuit alone carries a current of considerable electro-motive force. It consists of two wires only, a direct and return, extending from the dynamo directly to switches or binding posts at the motor. The operating circuit may always, therefore, be thoroughly protected. The contacting or switching circuit consists of two direct wires with a common return. By means of a pair of magnets (M^2, M^3) it operates the switch a^1, which reverses the current from port to starboard, or starboard to port, as desired. Port, or starboard, here means direction only. To put the helm from 30° starboard to 15° starboard the current would switch to *port*, the movement being toward the port side. The cut-out circuit breaks the contacting or switching circuit when the helm reaches the desired position, and the contacting circuit then switches or breaks the main or operating circuit, and so shuts down the motor. The contact plates of the contact arc at the tiller (or steering engine) are so arranged as to permit of adjustment for electric lead to allow for the time required to operate the mechanism, so that the cut-out circuit really acts a short time before the tiller reaches the desired point; but by the time the motor is shut down the tiller will have arrived at its proper place. The exact amount of lead required is determined by experiment and is adjustable. It would never exceed half a second of time, and would generally be much less.

The steering-box (Figs. 1 and 2) contains as many cut-out segments as are thought to be necessary to give perfect control of the helm, and the other cut-out arc at the tiller or steering engine is a duplicate of it as regards number of segments. One small wire is needed for each segment. The current in the contacting and cut-out circuits is very small, only sufficient to actuate the magnets operating the switches. These light currents are the only ones which need to go above the protective deck. If cut or short-

circuited no harm can result to the electric plant. Only one magnet—a weak one—on the operating lever, is located in the pilothouse, and no currents of high electro-motive force need be brought near the compasses. The magnet is only momentarily in operation and ought not to effect the compass.

Any number of steering stations may be located about the ship. All should be shut off except while in use. The accompanying drawings are those made for the Patent Office, in accordance with Patent Office practice, but do not exactly represent the apparatus as it really exists. The motors shown are not reversible, and the contacts are not exactly as used in the gears now under construction.

The advantages of electric control of the helm are numerous. With little additional weight any number of steering stations can be established, and they take up so little room that they may be placed anywhere. There is no restriction of position of the electric steering lever on account of leads for shafting or rope. The labor of steering is reduced to nothing, and in particularly difficult navigation the officer-of-the-deck may, if he chooses, steer the ship himself from any one of several steering stations, aloft if necessary, as a ship can be as readily steered, electrically, from the top or masthead as from the deck.

In the mechanism above described no parts are so delicate as to render them liable to injury by the concussion of firing or ordinary rough handling. All motions are positive, and all connections and contacts are accessible and adjustable.

The working of the apparatus is as follows: With the helm at 20° port, to put it to 30° starboard push the handle H (Fig. 1) to the right. The traveling block (Figs. 3 and 4) is held by the pressure of the springs s^6, s^{6a}, until the plate L^1 touches the spring l^1 and presses it against the head of the screw K^1. The function of the springs l^1 and l^2 is to furnish a yielding contact which will be maintained even if the lever H should spring back slightly. Through K^1 the circuit is completed and flows as follows: From the dynamo through b^2 to g, thence along top of steering lever to a, thence to L^1 to K^1 to n^1 (see Figs. 3 and 4), thence through s^{6a} to D^1, thence through w^1 to M^3 and back by w^1 (return wire) to the dynamo. Magnetizing M^3 the switch a^1 is drawn over and connects the main or operating current w with e^1. The operating

current then passes through b^1 to b^{1a} and back to the dynamo, driving the motor M^1 and drawing the nut N along the shaft. If the nut N carries the tiller-sleeve (instead of, as in the drawing, working a valve for a certain form of engine) the thread on the worm shaft S^1 would be in the other direction. Supposing the thread to be in the proper direction the tiller will then continue to move to starboard. The handle H, as stated above, is now at 30° starboard, when the tiller reaches d^3, which corresponds to 30° starboard (one edge of d^3 being at about 27° and the other at 33°, 3° representing the *lead*), the cut-out circuit is completed as lollows: From the dynamo to b^3, thence along the top of the steering lever H to M^4, thence to K, to S^5, to d^4 (Fig. 2), to d^3 (by its own individual wire in the cable C), thence by s^4 to the long arc c^4 and back to the dynamo by the single return wire w^2. When this current magnetizes the magnet M^4 on the steering lever H, it draws the lever-armature a over against the light spring shown and breaks the contacting circuit. When this circuit is broken the magnet M^3 is demagnetized, the switch a^1 is released and is thrown to middle position by the flat spring q, thus breaking the main circuit and stopping the tiller.

When the main or operating current is of considerable electromotive force (*i. e.*, when the apparatus is used as a steering gear and not as a controller) the switch a^1, instead of breaking it abruptly, shuts down the motor through graduated resistance in order to avoid sparking. The adjustable contact springs are shown in Figs. 8, 9 and 10.

The Edison General Electric Company are manufacturing the above apparatus under contract with the owners of the patents. The American patent bears the date of March 7, 1893; the British patent has been applied for, but probably will not be issued for some weeks yet.

VAN DUZER-MASON ELECTRIC STEERING GEAR.

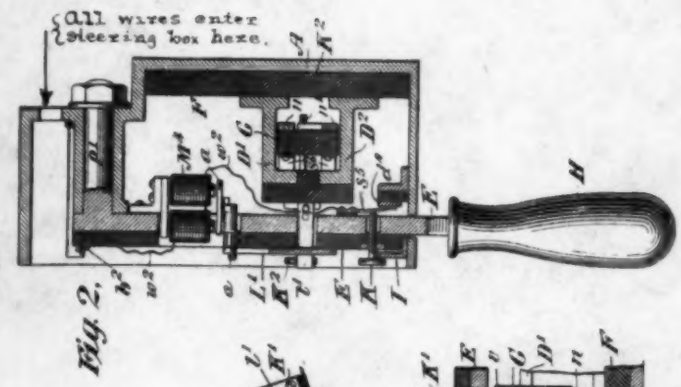

Fig. 2.

Fig. 5.

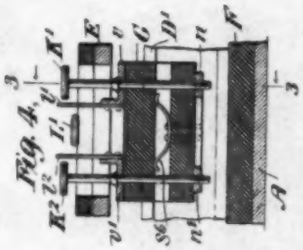

Fig. 4.

Fig. 6.

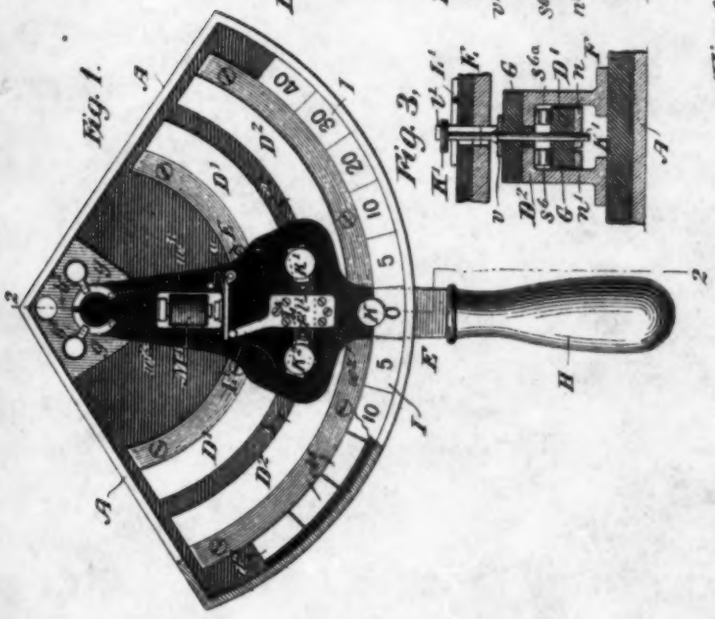

Fig. 1.

Fig. 3.

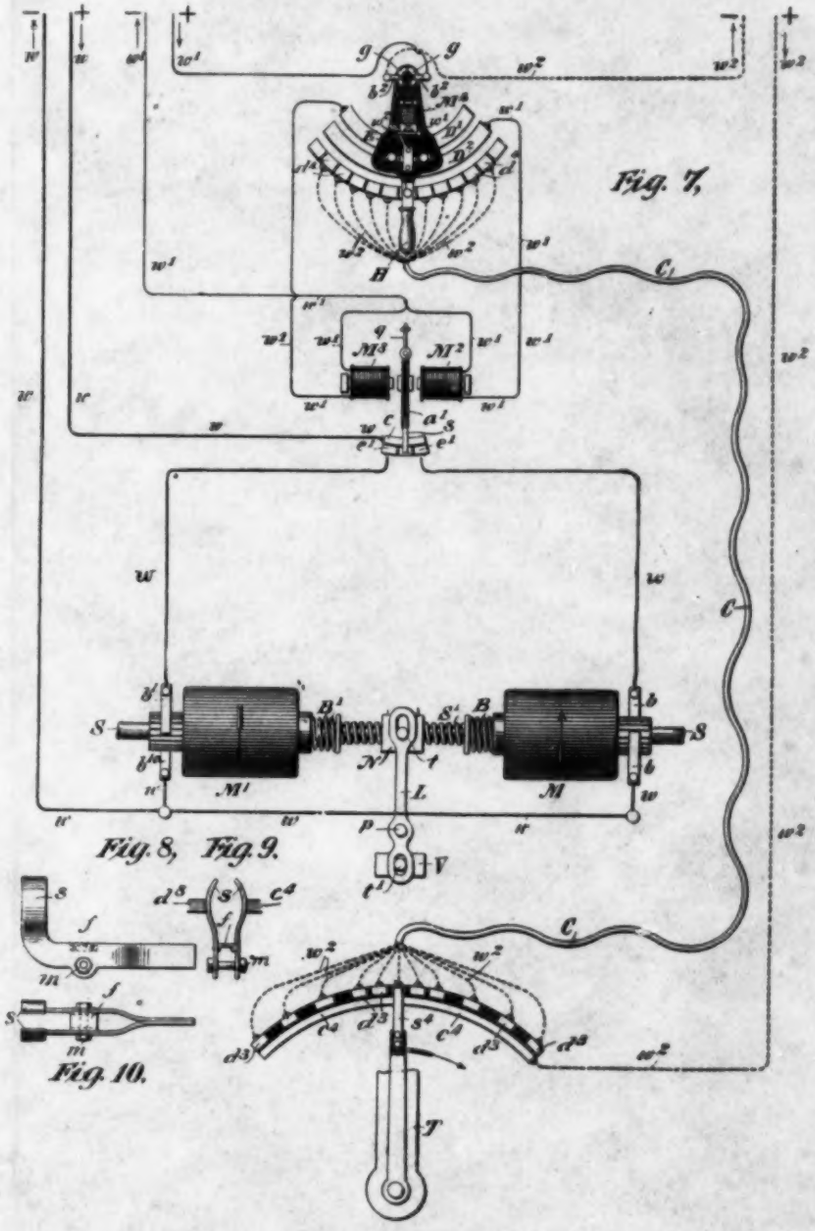

Fig. 7.

Fig. 8, Fig. 9.

Fig. 10.

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THE WHITE STRAIGHT-PULL RIFLE.

By First Lieutenant H. K. White, U. S. M. C.

The larger figure gives a general view of the breech, with details of the magazine and other parts in dotted lines. The clip is entered from above and pushed down into place by the thumb, being caught by the toe on the cut-off, as shown, this springing back to allow the projection on the back of the clip to pass below it As the clip goes down the cartridges force the follower down, compressing the feed spring. The follower has studs on each side working in circular guide grooves, so that as it moves up it is always held in position that the topmost cartridge may be in the proper position to feed into the chamber. The feed spring is of coiled wire, one end extending to the rear to bear under the follower. The other end is simply entered in its seat bored in the guard or magazine plate. When empty the clip drops out through the bottom of the magazine. Several clips are carried in the belt, charged with five cartridges each.

An improvement introduced in the clip allows it to be used with flanged cartridges and yet to be entered either side up, as the shape, combined with the new method of charging and the action of the feed in loading, causes the head of the topmost cartridge to lie forward of the one below it. Instead of entering the cartridges in the clip one at a time, the charging is accomplished in one operation from the front, the guide for the heads being formed by slitting the side plates of the clip, as shown by the dotted line, and springing in slightly the tongues thus formed. By this means the cartridge

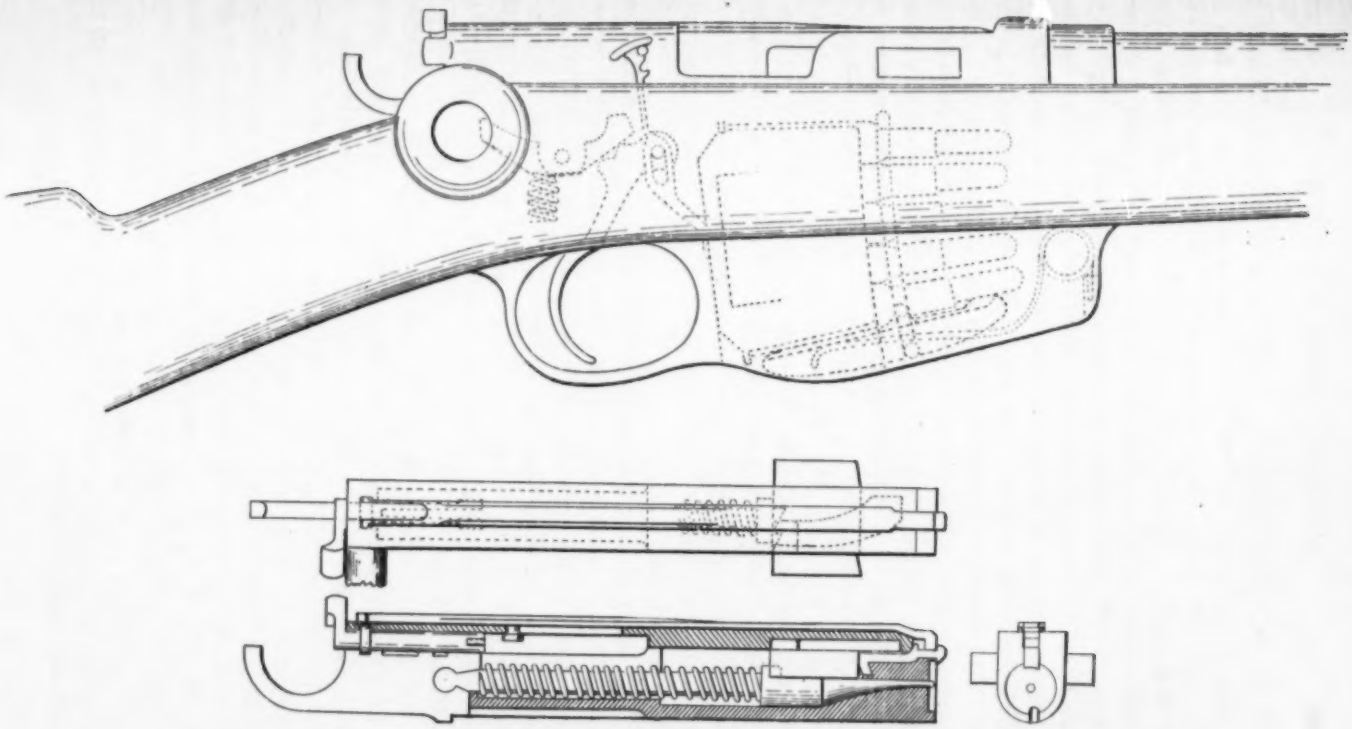
heads are allowed to pass by to the rear of the guiding edge, but are then caught and held from moving forward.

The clip detent moves up and down on the trigger pin or pivot as a guide, the upper part being provided with a head and two recesses to engage a pin on the receiver. The head is pressed down by the thumb to move the detent down to the position shown, when it is held by the pin entering one of the recesses. The clip is carried down at the same time so that the top cartridge is out of the line of movement of the bolt, and the magazine is "cut off." The piece can then be used as a single loader by dropping the cartridges into the receiver when the breech is open. The magazine can be thus "cut off" at any time, and very conveniently and quickly at the same time that the clip is inserted, by pressing down the cut-off. The magazine is put in action at any time by raising the cut-off with the first finger placed under its head; it can be plainly seen by the officer, showing whether the soldier has the magazine cut off or not. When a clip is not in, the follower forms a loading floor for use as a single loader.

The trigger has a double pull, at first easy until the sear is nearly disengaged from the firing pin; then, when the aim is exact (the fulcrum, or rather the leverage changing), a slight increase of pressure fires.

The bolt moves straight forward and back without turning. The lock is a Sharp block which moves laterally, being shown in the locked position, both ends then engaging abutments in the receiver to hold the bolt against pressure of the explosive. The block is moved to the right or left by the slide on the upper side of the bolt. A curved slot (shown in dotted lines) engages a pin on the block. When the slide is drawn to the rear by the hand on the bolt handle the block is shifted to the left or unlocked position, and when the slide is moved forward again the block is shifted to the locked position. As the block moves to the left, a projection on the firing pin, entering a recess in the block, is forced back until the block is over, when it springs forward into a smaller recess in the block to hold the latter. The firing pin is thus retracted and can never touch the cartridge except when the projection on the firing pin can enter the deep recess, *i. e.*, when the bolt is locked.

The firing pin is in two parts, united by a dovetail after the spring is put on and is inserted from above into its recess in the



bolt proper. This has its rear part cut down cylindrically to form a spindle on which the bolt slide reciprocates. The rear part of the slide is the same shape outside as the bolt and is bored out to fit the spindle. The forward part extends over the bolt as a flat plate having the curved slot above mentioned. The slide is also cut out in the rear part for the safety locking arrangement and the guide pin of the extractor locking bar. This bar is free to move with the bolt, in a slot cut in the rear part of the receiver over the bolt and its action is as follows: The bolt handle being drawn back the block is unlocked, a powerful wedge or cam action assisting the extraction, and the bolt as a whole is carried to the rear and the empty shell ejected. On moving the bolt forward, when it is nearly home, a projection on each side of the locking bar engages the receiver, and by slight spring action is held back by friction while the bolt moves forward. The extractor hook is then free to pass over the cartridge head. During the final forward motion of the slide, after the bolt proper is locked, the bar is forced forward over the extractor, entering the extractor recess under the receiver so as to be held down by the latter, thus locking the extractor positively over the cartridge head.

The safety locking mechanism is inserted in the slide from below and held from turning when in locked or unlocked position by two projections at the forward end entering slots in the slide, the end being split to allow these to spring in when turned. A collar engages slots in the firing pin to lock it either at full cock or not, and when turned over to lock the handle engages the receiver to hold the bolt fast.

All the parts interlock and no screws or screw threads are required in the breech mechanism. The locking block is first taken out in taking down the bolt. To allow the block to pass its abutment on the left side and the bolt to move back and forward, the block has a slot cut in its upper side, corresponding with the abutment when unlocked. The neck thus formed on the block moves backward and forward in a slot cut in the receiver. When the bolt is half-way back, if the firing pin is retracted to disengage its projection from the block, the latter may be taken out from the right side. The bolt can then be withdrawn from the receiver and be taken completely apart; or, by inserting the block in the bolt again, all the parts are locked together.

With the new smokeless powders the barrel becomes very hot. A part of the invention is a method of cooling it. An air space is arranged all around the barrel, a cover over it being continued as a cylinder around the muzzle. An annular space or orifice is formed around the muzzle between it and the cover. The gas, on discharge, rushing past the orifice, draws out the heated air from the space around the barrel, and fresh, cool air enters this space at the breech.

In this way is formed a complete system, the breech mechanism of but few parts, uncomplicated, and quickly taken apart and assembled. Besides the insertion of the cartridge as a single loader, or of the clip when that is used, but two motions of the hand, backward and forward, are required, making it convenient to fire rapidly without removing the piece from the shoulder.

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THE EFFECT OF ALTERATION OF PROPELLERS ON THE SPEED OF VESSELS.

By J. J. O'NEILL, Member of the Society of Naval Architects and Associate Member of the Naval Institute.

The efficiency of the propeller is one of the primary and most important factors in steam propulsion, to which a great deal more attention ought to be paid. Too often a vessel goes on trial with screws totally unadapted for the speed intended; and when the same has been found wanting, other screws are substituted, whose elements are entirely different, which realize anticipation.

Whether success results from either alteration of diameter or pitch, or both, is alike a mystery.

This is an undesirable state of things, and if I am able to show the variations in speed obtained with different propellers, power being constant, on a given ship under precisely similar conditions, in which these variations can be assigned to their true cause, something will have been gained.

The importance of carefully conducted experiments must here be urged, as the value of proper, authenticated data cannot be overestimated, more especially in dealing with high-speed vessels. This can only be obtained, in so far as the propeller problem is concerned, by a systematic trial of screws, on a given ship, in which one factor alone varies. It is suggested that a propeller of a given diameter and pitch be fitted and progressive trials run, commencing with a pitch ratio of 1, and then varying the pitch by $\frac{1}{10}$ until the ratio is 1.5, the diameter remaining constant; then

reversing the process by varying the diameter, the pitch being constant. Ten progressive curves will then be obtained, showing the variations due to the alteration of each factor, which can be combined by a system of cross curves, similar to those used in stability calculations, whose value is incalculable, and which would permit of the proper propeller being chosen, at least within the limits of the experiment, for the given vessel.

It will then be found that a point exists, which it is proposed to call the *neutral point*, where any of the propellers experimented upon are of equal value for speed purposes; but that one alone is desirable when efficiency of machinery is considered, less wear and tear, and consequent prolongation of life, obtaining when the revolutions are the least possible. Further, it will appear that below the limit of the *neutral point* a relatively large propeller running comparatively slowly is the more efficient; whilst above this point, or at high speeds, a smaller propeller running quickly is more desirable for speed efficiency. The only question, then, to determine is the speed at which the conditions change.

This, of course, varies according to the type of vessels; but in ships of usual form, like war vessels, ranging from 3000 tons to 9000 tons displacement, all the data procurable seems to indicate that the point is 16½ to 18 knots, respectively. This variation is very slight when the size of vessels between these limits is considered.

It will be perfectly evident, after viewing the progressive speed curves appended, that difficulty must naturally exist in determining the necessary horse-power required to drive vessels at given speed, when the variations of speed, with similar power, due to alteration of propellers, is so marked.

No system of admiralty co-efficients of performance can obtain under these circumstances: and, in connection with these co-efficients, it may be well to state here that it will be found that one co-efficient frequently represents two distinct speeds, very wide apart, on the progressive speed curve; and further, they are absolutely of no value whatever when it may be shown that two vessels of similar type, having displacements in the ratio of 1 to 2, require the same power to obtain the same speed. In applying admirality co-efficients it is assumed, and wrongfully so, that the propulsive efficiency is constant; that is to say, that the proper propellers have

been fitted, which the curves appended clearly show may not have been the case. Again, given the progressive speed curve of a vessel, it must be clear that, in developing the ship to other dimensions, a time can never come when the same power drives both at equal rates; or two ships of equal displacements, midship areas and surfaces, having two spots on the curves, *viz.*, at 13 and 16 knots, indicating the same power, giving the same co-efficient, and yet below, between and above, having different co-efficients is inadmissable. It may further be urged that, the co-efficients being found true for two speeds on identical ships, no deviation of propellers can obtain; yet this is so, for the Scout has propellers different from those of the vessel here given, although at two distinct speeds both vessels obtain the same speed with the same power.

It is obvious, then, that any such system of computing necessary powers of varying speeds, based upon other similar vessels' performances, whose propeller elements may be entirely dissimilar, is entirely unreliable.

The method recently adopted for determining the speed from a revolution curve, after having standardized the screws, and extending the progressive speed revolution curve beyond the limits of observation, sometimes unreasonably beyond, as in the case of the Monterey, is also unsatisfactory.

Firstly, because it necessarily assumes that the propellers are the best possible for the given conditions, which, in the light of actual experiment, is exceedingly doubtful, and more especially so when we consider the case of the Philadelphia and Baltimore. These vessels are in the tabulated statement, given in the General Information Series No. XI., as identical ships of similar displacement, draft, and propellers, and yet the Baltimore develops 15 per cent. more power on three revolutions per minute less, and secures an increase of speed of four-fifths of a knot. The Terpsichore obtained 20 knots with the same power as the Philadelphia, and with the same power as the Baltimore can reach 20½ knots instead of 20 knots as given for that vessel. These results all show that the propeller problem is not yet exhausted.

Secondly, it will be found unreliable when applied to high speeds, like those obtained by torpedo-boats and vessels of small dimensions and high speed. The progressive curves of power on these vessels show decided and well marked deviations from a fair

curve at high speed, the reasons for which being now generally known—the increase of speed at the high limits being greater than that immediately below for the same increase of power; or, in other words, the same increment of power at the extreme limits of the curve giving a greater increase of speed than immediately below that limit.

This would not be apparent on the preliminary trials, where the maximum speed may not be sought for, and hence any deduction from revolutions only at the high speeds would be erroneous and misleading.

The true speed can only be deduced from any plotted curves within the limits of observation.

Everything, therefore, points to the necessity of *tank experiments*, in which not only the model of the vessel but of the screws should be put through a series of carefully conducted experiments at varying speeds, plotting results, and then finally running the actual vessel under similar conditions and comparing the theoretical with the practical curve, the difference giving the efficiency of machinery. When this has been done for varying types and the machinery efficiency determined, the prediction of results will be comparatively easy.

The method of designing vessels, and their machinery too, requires modification. The power obtained in the engine-room is no indication of the true condition of things and is relatively of no value. It is the power exerted by the propeller that determines the true value of power; and on its efficiency, as is clearly shown by the curves appended, the efficiency of the machinery.

It becomes, therefore, of primary importance that, a ship being given, the most vital basis of the design should receive the best attention. At present the only way in which some definite basis can be determined is in the manner pointed out.

It may be that the present type of ship is not the most perfect for obtaining speed, but, under the present conditions, the propeller is the *most* vital element of the design.

The behavior of the New York further exemplifies the deductions of this paper. This vessel obtained 21 knots with 136 revolutions, developing about 17,000 I. H. P.

It can safely be said that the only defense for this high rate of running machinery can be *increased efficiency of propulsion*, and the

records do not show that any such desirable result has been reached.

As far as can be judged, the machinery ran to its highest limit of speed under the conditions of trial, but for 20 knots, the *designed speed*, 90 revolutions would have been ample; with 110 revolutions 21 knots; whilst, had the propeller been otherwise, *22 knots* ought to have been reached on this power and revolutions. In other words, the New York's dimensions warrant the assertion that its *efficient speed* with the power developed is 22 knots, and the non-attainment of this should induce us to seek the cause. A reduction of diameter of propeller and increased pitch is the solution. Further, the wave formations on trial make evident to those experienced in such matters that a higher speed than that obtained is possible. These wave formations are the true indications of efficiency of the ship and machinery, and should be more carefully studied. When it is considered that $400,000 is involved in this one question, the importance of the problem can be readily appreciated.

The question of the design of the screws becomes of intense importance in the case of the Columbia, where triple screws are fitted, and their efficiency as compared with twin screws will largely depend on their dimensions.

As this vessel is essentially a high speed one, her *raison d'être* being that she be capable of outstripping, or at least overtaking, any vessel afloat, it must be urged, in the light of the advent of the Campania, that special attention be directed to this matter. Small propellers will be undoubtedly found best, and if these be fitted there can be no doubt, other things being equal, that 23 knots can be obtained, which is the true speed of this vessel.

The financial aspect of the question is worth considering even from a premium point of view. In the Columbia 21 knots is the contracted speed, and this enables a premium of $400,000 to be secured. This also applies to the New York. In the coast-line battleships of the Indiana class, whose machinery is designed to develop 9000 I. H. P., 15 knots is fixed at the speed with 128 revolutions. This great rate of running is unnecessary and injurious.

A larger propeller with 100 revolutions would be best for the machinery, giving a greater duration of life, and with this power 17 knots can be obtained, involving a premium of $200,000. The Bancroft is another case in point, where 2½ knots were obtained

over anticipation, with a premium of $500,000, due entirely to the efficiency of the propeller.

Again, the influence of the speed factor is more clearly seen in the case of the sea-going battleship Iowa, whose machinery weights permit of 15,000 I. H. P. being developed with 100 revolutions under forced conditions, whereas 16 knots is the contemplated speed with 9000 I. H. P., any increase securing premiums.

With suitable propellers 18 knots can be obtained, or 12 per cent. over anticipation, giving a premium of $200,000; under natural draft 17 knots will be reached on the specified power, which means $100,000.

This, I anticipate, will show the importance of the subject financially, and perhaps it may be well to further show what might have been done in the foregoing cases, accepting the conditions of the design as to protection, speed, armament, coal supply, etc.

Speed being the most essential factor, with that as basis, smaller ships can be built, at an enormously decreased cost, with greater manœuvring power, with all the other elements as required. Or on the same displacement, ships with from 15 to 20 per cent. greater protection and 50 per cent. greater coal supply can be produced. In the case of the Iowa the results possible are enormously in excess of the present anticipations. On same displacement, a smaller ship, having *twice* the coal supply of the Indiana, with protection greatly in excess of that vessel, can be produced, still securing a premium of $100,000. The Monterey's history is somewhat peculiar, she being designed for a speed of 15 knots, attaining only 13.6 on trial with 5244 I. H. P. and 161½ revolutions.

Yet, if speed were a primary and vital element, one can hardly realize such an unusually dimensioned vessel hoping to reach this speed. This vessel is only a *nine knot* one, that being her most efficient speed, and when a higher speed than this is sought it is at the expense of every other factor in the design; manœuvring power, steady gun platform and protection being sacrificed. When this vessel ran at speeds above 9 knots, the waves generated exposed the under surface of her armored protection for three-fourths the vessel's length, thus defeating the object for which it was placed there; in fact, it is a hindrance rather than otherwise to the vessel. This weight could have been utilized in increasing the length of the vessel and, by erecting a temporary bulwark in wake of the bow

wave, thus keeping it within the limits of the deck, the speed could have been largely augmented. Even as it is the propellers are 2′.0 too large in diameter, and if these be altered, 15 knots can be obtained on the power specified.

The subject then is of some moment; but, apart from its financial aspects, it appears to me that in designing ships the object should be to secure the *maximum effect on a minimum power and revolutions*; and this can only be secured by close attention to machinery details, as the form of high speed vessels leaves nothing to be desired; and, in short, is not of such value as is customarily supposed. The principal factor of the machinery is obviously *the propeller*; the curves appended show the marked differences due to the alteration of this element; the saving effected has likewise been shown to be enormous; and, therefore, it appears desirable to study this branch of the subject as zealously as possible.

The object in this paper has been, by giving actual results of trials, to encourage enquiry. If it should succeed in creating a desire to investigate this important question more closely, that object will have been attained.

Description of Vessel and Conditions of Trial.

	Feet.	Inches.
Length between perpendiculars	224	0
Breadth, moulded	34	0
Depth "	20	0
Draft, forward	12	6
" aft	15	6
" mean	14	0
Displacement	1600 tons.	

The trials were run with and against the tide, on a measured course of 1 mile on the north-east coast of England. Nixon's navigation coal was used on each occasion, the ship's bottom being in perfect condition. On the official trial, run in December, 1885, the mean of 6 runs with natural draft gave 17.642 knots with 119 revolutions and 4740 collective H. P. With Biles' indicator the speed was 17.66, and revolutions 120. Subsequently the forced draft trial gave a speed of 18.4 knots with 128 revolutions and a collective H. P. of 6200, 260 H. P. of which was absorbed by the auxiliary machinery.

In all cases, the vessel was trimmed to designed draft; displacement, surface, etc., all being constant, and, assuming that the conditions of trial were fairly similar, any variation obtained may be reasonably assigned to the only factor altered.

Diagram I. shows the power speed curves when the diameter was constant; the propeller efficiency curves to the left plotted to *D* and *A* bases, respectively, show the variations in speed, power being constant. The revolution curves are plotted on power basis. It will be seen that at 17 knots the propellers *A*, *B*, *C* and *D* are equal, 3650 I. H. P. being required in each case. When 6000 I. H. P. is reached, however, the variations in speed are very great, *D* obtaining three-fourths of a knot more than *B*. The dimensions of the propellers were as follows:

	Pitch.	Diameter.	Projected surface.	Pitch ratio.
A	15.9	12.6	52 sq. feet	1.26
B	16.6	12.6	47 "	1.32
C	16.9	12.6	46 "	1.34
D	18.0	12.6	46 "	1.44

Propeller *D* was finally chosen for the vessels.

Diagram II. shows the effect of variation of diameter, pitch being constant. At 16½ knots both required the same power to drive the ship, but when 6000 I. H. P. were developed *E* was found to gain three-fourths of a knot on *B*. The dimensions are as appended:

	Pitch.	Diameter.	Projected surface.	Pitch ratio.
B	16.6	12.6	47 sq. feet	1.32
E	16.6	13.0	49 "	1.27

Diagram III. shows variations due to the diameter varying, pitch constant, with screws of different dimensions from those shown in Diagram II.

	Pitch.	Diameter.	Projected surface.	Pitch ratio.
C	16.9	12.6	46 sq. feet	1.34
F	16.9	11.9	42 "	1.43

Diagram IV. shows variations due to alteration of pitch, diameter being constant; unfortunately, only low speeds were tried, but they are here given to complete the group:

	Pitch.	Diameter.	Projected surface.	Pitch ratio.
G	18.0	11.9	43 sq. feet	1.53
F	16.9	11.9	42 "	1.43

Diagram V. shows variations due to the variations of diameter, pitch remaining constant:

	Pitch.	Diameter.	Projected surface.	Pitch ratio.
G	18.0	11.9	43 sq. feet	1.53
D	18.0	12.6	46 "	1.44

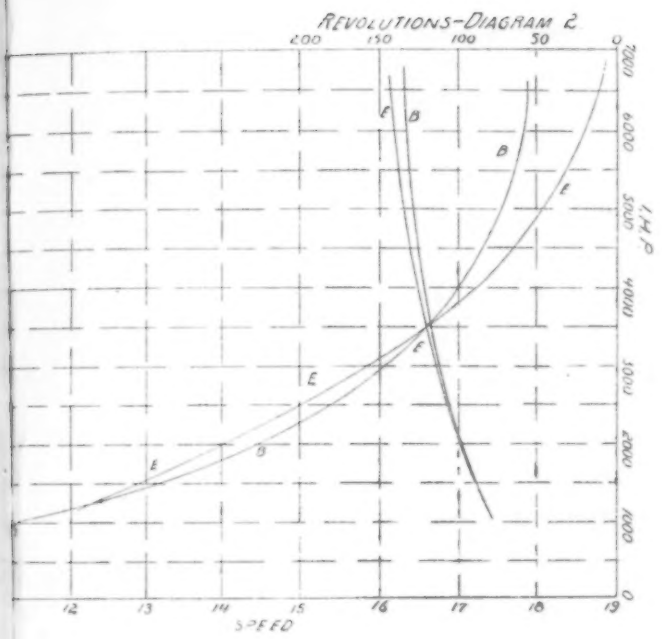
Diagrams VI., VII., VIII., group propellers of nearly equal pitch ratio together, so that the influence of alteration of both dimensions in a constant ratio can be shown.

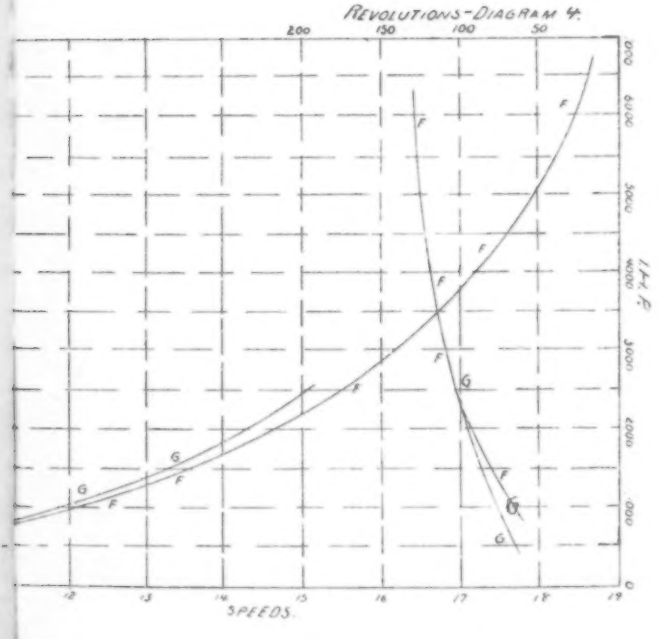
The propellers experimented upon are as follows:

	Pitch.	Diameter.	Projected surface.	Pitch ratio.
A	15.9	12.6	52 sq. feet	1.26
B	16.6	12.6	47 "	1.32
C	16.9	12.6	46 "	1.34
D	18.0	12.6	46 "	1.44
E	16.6	13.0	49 "	1.27
F	16.9	11.9	42 "	1.43

The groupings being respectively as follows:

Diagram VI., *A* and *E*, with pitch ratio.....1.26 and 1.27.
" VII., *B* and *C*, " " .....1.32 and 1.34.
" VIII., *D* and *F*, " " .....1.44 and 1.43.


REVOLUTIONS-DIAGRAM 2
200
150
100
50
0
I.H.P.
SPEED
12
13
14
15
16
17
18
19
E
B
F


REVOLUTIONS-DIAGRAM 4.
200
150
100
50
0
I.H.P.
SPEEDS.
12
13
14
15
16
17
18
19
F
G

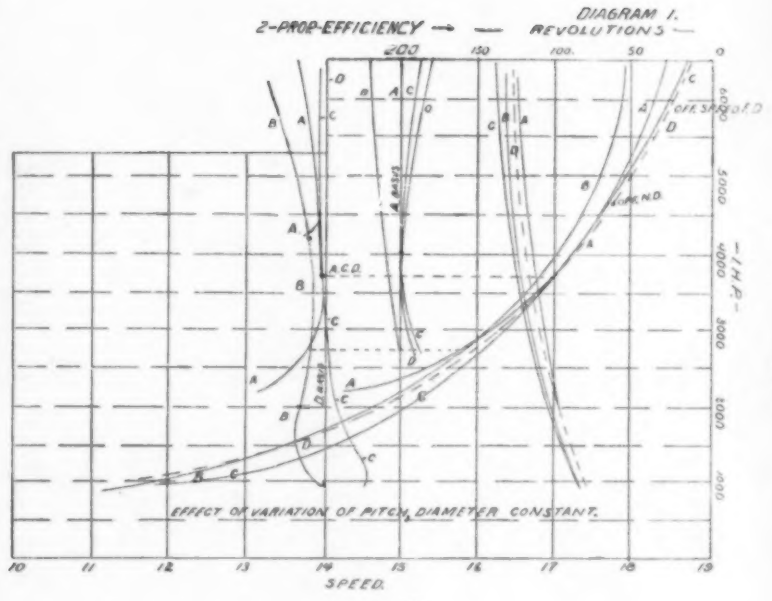


DIAGRAM 1.
2-PROP-EFFICIENCY →
← REVOLUTIONS
200
150
100
50
0
OFF SPEED
LOAD
A.C.D.
EFFECT OF VARIATION OF PITCH, DIAMETER CONSTANT.
H.P.
SPEED.
10
11
12
13
14
15
16
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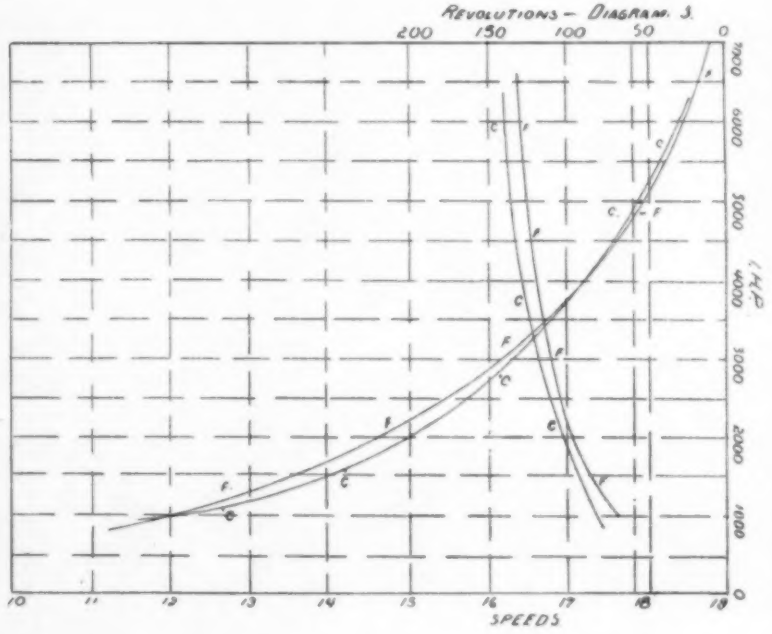
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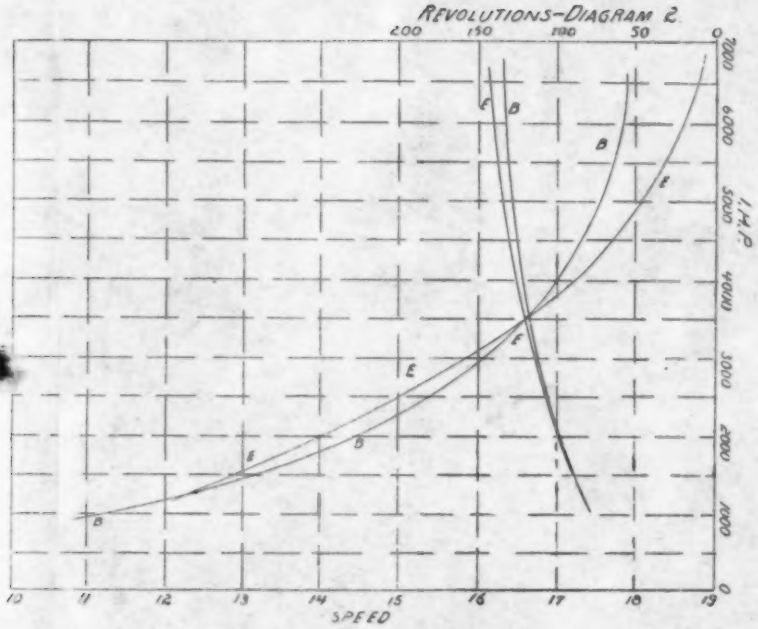
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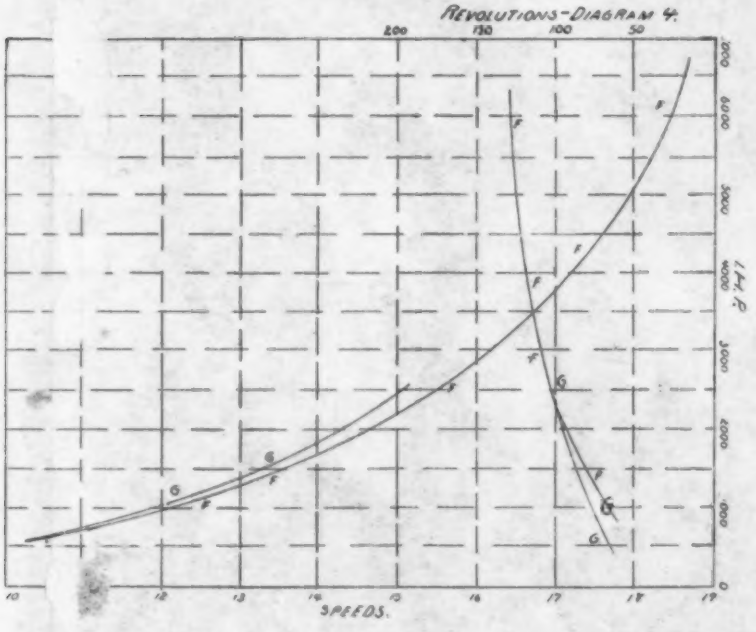
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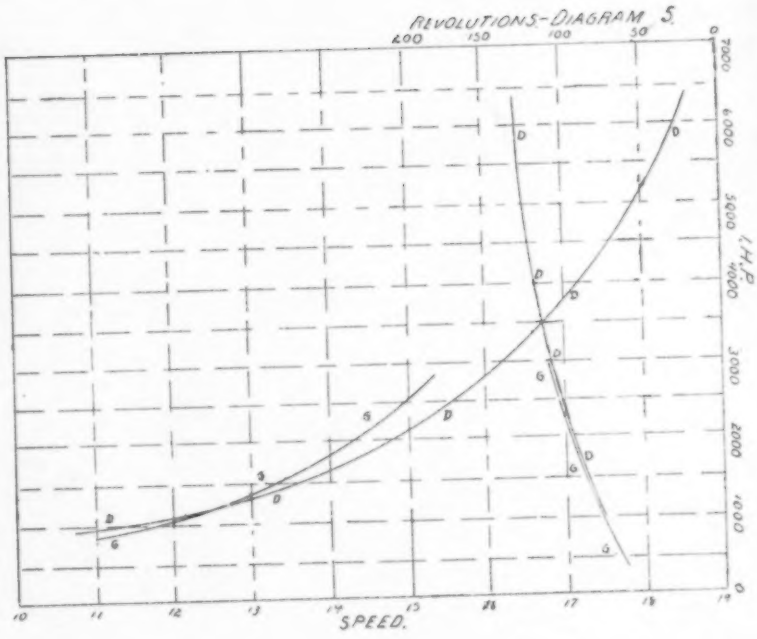
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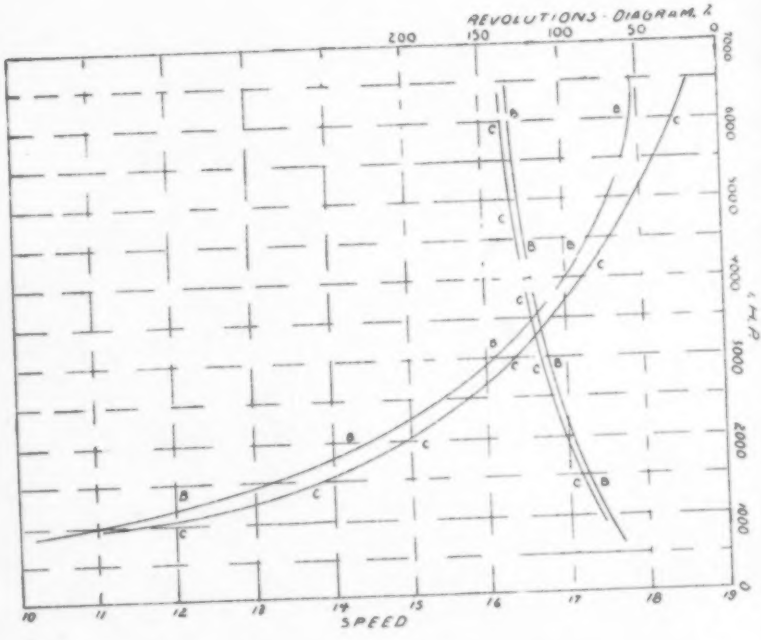
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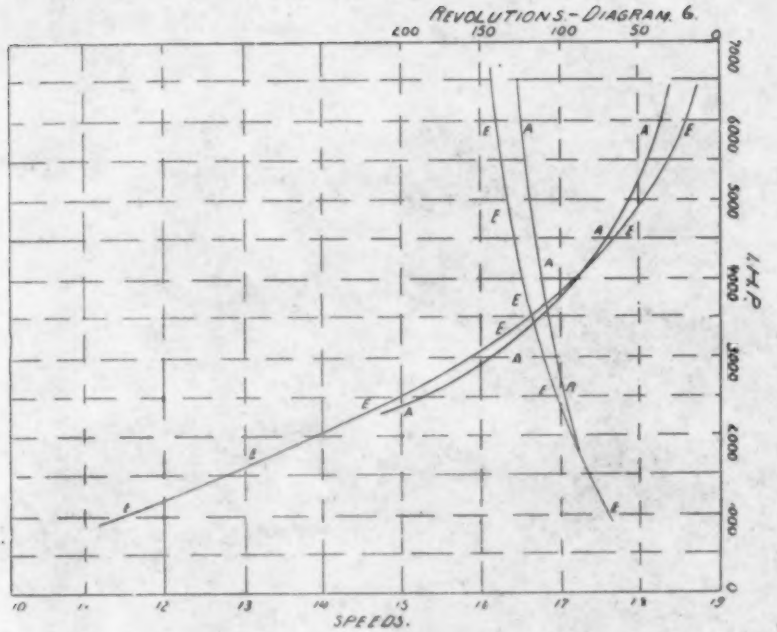
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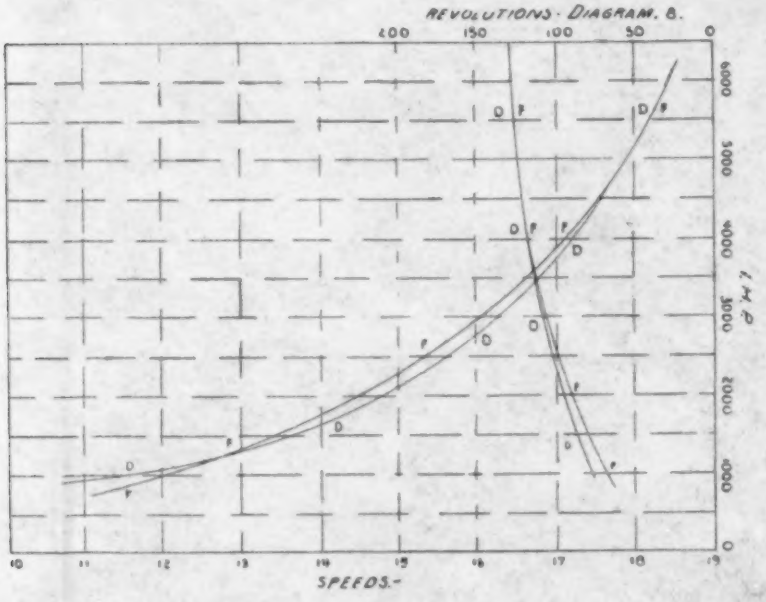
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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NEGATIVE-RECIPROCAL EQUATIONS.*

By Commander J. E. Craig, U. S. Navy.

Read before the New York Mathematical Society, June 3, 1893.

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1. There is a type of equations that remain unaltered when x is changed into $-\frac{1}{x}$.

From the character of the roots, and from the relation that such equations bear to those named by the text-writers "reciprocal equations," the suggestive name for this type is *negative-reciprocal equations.*

In order to preserve a clear distinction, "reciprocal equations" will herein be referred to as *positive-reciprocal equations.*

To find the conditions inherent in negative-reciprocal equations.— Let the proposed equation be

$$x^n+p_1x^{n-1}+p_2x^{n-2}+p_3x^{n-3}+\ldots +p_{n-3}x^3+p_{n-2}x^2+p_{n-1}x+p_n=0; \quad \ldots \quad (1)$$

substitute $-\frac{1}{x}$ for x, and divide by p_n, whence we have

$$(-x)^n+\frac{p_{n-1}}{p_n}(-x)^{n-1}+\frac{p_{n-2}}{p_n}(-x)^{n-2}+\frac{p_{n-3}}{p_n}(-x)^{n-3}+\ldots -\frac{p_3}{p_n}x^3+\frac{p_2}{p_n}x^2-\frac{p_1}{p_n}x+\frac{1}{p_n}=0. \quad \ldots \quad (2)$$

* This discussion results directly from investigation of a navy-professional subject that gave rise to equations of the peculiar kind. Having no clue to the simplifying of their solution, the roots were found only after much unnecessary work. The disclosing of the

2. If n be odd, the identity of equations (2) and (1) requires $p_n = -\frac{1}{p_n}$, whence $p_n = \pm\sqrt{-1}$. Therefore, negative-reciprocal equations of odd degree will be dismissed from further consideration, as involving imaginary coëfficients. This is in contrast with the case of positive-reciprocal equations, in which the coëfficients are real whether n be odd or even.

If n be even and equations (1) and (2) be identical, $p = \frac{-p_{n-1}}{p_n}$, $p_2 = \frac{p_{n-2}}{p_n}$, $\ldots$ $p_{n-1} = \frac{-p_1}{p_n}$, and $p_n = \frac{1}{p_n}$, whence $p_n = \pm 1$. Taking, in turn, the two values of p_n, we obtain two forms of negative-reciprocal equations, thus:

Form (I.).—When $p_n = 1$, then $p_1 = -p_{n-1}$, $p_2 = p_{n-2}$, $p_3 = -p_{n-3}$, $\ldots$ $p_{n-3} = -p_3$, $p_{n-2} = p_2$, $p_{n-1} = -p_1$; and we have

$$x^n + p_1 x^{n-1} + p_2 x^{n-2} + p_3 x^{n-3} + \ldots - p_3 x^3 + p_2 x^2 - p_1 x + 1 = 0. \quad \ldots \quad (3)$$

Form (II.).—When $p_n = -1$, then $p_1 = p_{n-1}$, $p_2 = -p_{n-2}$, $p_3 = p_{n-3}$, $\ldots$ $p_{n-3} = p_3$, $p_{n-2} = -p_2$, $p_{n-1} = p_1$; and we have

$$x^n + p_1 x^{n-1} + p_2 x^{n-2} + p_3 x^{n-3} + \ldots + p_3 x^3 - p_2 x^2 + p_1 x - 1 = 0. \quad \ldots \quad (4)$$

3. From the preceding article, we see that to have a negative-reciprocal equation, with real coëfficients, the necessary conditions are: (1st) The degree of the equation must be even; (2d) the coëfficients of the corresponding terms, counting from the beginning and end of the first member of the equation ($f(x) = 0$), must be equal numerically, and (3d) must be alternately alike and unlike in sign, giving rise to two forms of the equation, (I.) when the extreme terms have the same sign, and (II.) when they have opposite signs; (4th) the middle term $\left(p_m x^m, \text{ where } m = \frac{n}{2}\right)$ must be absent if the equation be of the first form and m be odd, or if of the

character of the roots thus obtained led to investigation for an easier solution, since the text books did not supply what was needed. The results, found useful in one direction of professional work, may prove useful to the navy officer in various directions, therefore the paper is printed here.

second form and m be even; for then the conditions giving equations (3) and (4) require $p_m = -p_m$, therefore $p_m = 0$.

4. From the identity of the proposed equation with that derived by substituting $-\frac{1}{x}$ for x, it is evident that the negative-reciprocal of any root, as a root itself, will satisfy the equation. This would indicate that the roots occur in pairs, of the form $a, -\frac{1}{a}$; $b, -\frac{1}{b}$; . . . and this condition must obtain except in the case of a root that is its own negative-reciprocal.

5. For convenience of treatment, negative-reciprocal equations of the dimensions $2m$ will be divided into two classes, as follows:

I. The equation will be of the first class, (a_1) if m be even and the first and last terms have the same sign, or (a_2) if m be odd and the extreme terms have different signs.

II. The equation will be of the second class, (b_1) if m be odd and the extreme terms have the same sign, or (b_2) if m be even and the extreme terms have different signs; and in this class the middle term must be absent.

From equation (3), substituting $2m$ for n, the equation of the second class (b_1), when m is odd, may be written in the form

$$x^{2m} + 1 + p_1 x(x^{2(m-1)} - 1) + p_2 x^2(x^{2(m-2)} + 1) + p_3 x^3(x^{2(m-3)} - 1) + \ldots = 0. \quad . \quad . \quad . \quad (5)$$

In equation (5) the sums of the odd powers of x^2 and 1, and the differences of the even powers, occur as factors so as to render the equation divisible by $x^2 + 1$.

Similarly, from equation (4), for (b_2) when m is even,

$$x^{2m} - 1 + p_1 x(x^{2(m-1)} + 1) + p_2 x^2(x^{2(m-2)} - 1) + p_3 x^3(x^{2(m-3)} + 1) + \ldots = 0; \quad . \quad . \quad . \quad (6)$$

and, as before, we have the sums of the odd powers, and the differences of the even powers of x^2 and 1.

Therefore, every negative-reciprocal equation of the second class contains the factor $x^2 + 1 = 0$, from which we derive the two isolated roots, $\sqrt{-1}$ and $-\sqrt{-1}$, each being the negative-reciprocal of itself. Since these roots are imaginary, they occur only together, and as single roots in the equation of the second class; unlike the case of isolated roots in positive-reciprocal equations, in which

1 or -1 may be a root, thus giving an odd-degree reciprocal equation; or they may occur together, giving an even-degree positive-reciprocal equation, of the second class as commonly distinguished.

Dividing a negative-reciprocal equation of the second class by x^2+1, to remove the isolated roots, the character of the roots makes the quotient a negative-reciprocal equation. Moreover, the reduced equation will be of the first class, since the signs of the extreme terms of the quotient remain the same as in the given equation of the second class, while m changes from odd to even, or *vice versa;* the condition (b_1) becoming (a_1), or (b_2) becoming (a_2).

6. The divisor x^2+1 put equal to zero gives the simplest form of negative-reciprocal equations of the second class, corresponding to $m=1$.

The simplest form of negative-reciprocal equations of the first class is the quadratic $x^2-1=0$; in which the middle term has zero for its coëfficient, though such condition is not required, the next simplest equation of this class taking the form $x^2-Ax-1=0$, in which $A=a-\frac{1}{a}$, where a is a root.

It may be of interest to note that while $x^2+1=0$ and $x^2-1=0$ are both negative-reciprocal equations, they are, at the same time, positive-reciprocal equations: that though $x^2+1=0$, as a factor, enters every negative-reciprocal equation of the second class, yet its roots are positively reciprocal: that though $x^2-1=0$, as a factor, enters every positive-reciprocal equation of the second class of an even degree, yet its roots are negatively reciprocal: that $x^2-1=0$ as a negative-reciprocal equation is of the first class, giving a pair of negatively reciprocal roots, 1 and -1; but as a positive-reciprocal equation it is of the second class, giving the two roots as isolated: that $x^2+1=0$ as a positive-reciprocal equation is of the first class, giving a pair of positively reciprocal roots, $\sqrt{-1}$ and $-\sqrt{-1}$; but as a negative-reciprocal equation it is of the second class, giving the two roots as isolated.

7. *A negative-reciprocal equation of the first class can be depressed to an equation of half its dimensions.*

With unity for the coëfficient of the first term, the given equation will be in one of two forms (Article 5, I.); thus—

(a_1) when m is even,

$$x^{2m}+p_1x^{2m-1}+p_2x^{2m-2}+p_3x^{2m-3}+\ldots+p_mx^m\ldots$$
$$-p_2x^3+p_2x^2-p_1x+1=0;\quad\ldots\quad(7)$$

(a_2) when m is odd,

$$x^{2m}+p_1x^{2m-1}+p_2x^{2m-2}+p_3x^{2m-3}+\ldots+p_mx^m\ldots$$
$$+p_3x^3-p_2x^2+p_1x-1=0. \quad . \quad . \quad . \quad (8)$$

Dividing equations (7) and (8) by x^m, and collecting in pairs the terms that are equidistant from the beginning and end, we have—when m is even,

$$x^m+\frac{1}{x^m}+p_1\left(x^{m-1}-\frac{1}{x^{m-1}}\right)+p_2\left(x^{m-2}+\frac{1}{x^{m-2}}\right)$$
$$+p_3\left(x^{m-3}-\frac{1}{x^{m-3}}\right)+\ldots+p_m=0; \quad . \quad . \quad . \quad (9)$$

when m is odd,

$$x^m-\frac{1}{x^m}+p_1\left(x^{m-1}+\frac{1}{x^{m-1}}\right)+p_2\left(x^{m-2}-\frac{1}{x^{m-2}}\right)$$
$$+p_3\left(x^{m-3}+\frac{1}{x^{m-3}}\right)+\ldots+p_m=0. \quad . \quad . \quad . \quad (10)$$

From the last two equations, we see that every term containing x to an even power is connected with the reciprocal of the same power by the positive sign, and that every odd power of x is connected with its reciprocal by the negative sign; and we may make use of two general relations, A and B, for deducing the depressed equation in terms of powers of

$$x-\frac{1}{x}=z. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

$$A\begin{cases}\left(x^{n-1}-\frac{1}{x^{n-1}}\right)\left(x-\frac{1}{x}\right)=\left(x^n+\frac{1}{x^n}\right)-\left(x^{n-2}+\frac{1}{x^{n-2}}\right); \therefore \\ x^n+\frac{1}{x^n}=\left(x^{n-1}-\frac{1}{x^{n-1}}\right)z+\left(x^{n-2}+\frac{1}{x^{n-2}}\right). \quad . \quad . \quad . \quad (12)\end{cases}$$

$$B\begin{cases}\left(x^{n-1}+\frac{1}{x^{n-1}}\right)\left(x-\frac{1}{x}\right)=\left(x^n-\frac{1}{x^n}\right)-\left(x^{n-2}-\frac{1}{x^{n-2}}\right); \therefore \\ x^n-\frac{1}{x^n}=\left(x^{n-1}+\frac{1}{x^{n-1}}\right)z+\left(x^{n-2}-\frac{1}{x^{n-2}}\right). \quad . \quad . \quad . \quad (13)\end{cases}$$

By A we have from (12), and then from (11),

$$x^2+\frac{1}{x^2}=\left(x-\frac{1}{x}\right)z+\left(x^0+\frac{1}{x^0}\right)=z^2+2; \quad . \quad . \quad (14)$$

By B from (13), $x^3-\frac{1}{x^3}=\left(x^2+\frac{1}{x^2}\right)z+\left(x-\frac{1}{x}\right)$, and from (11) and (14), $x^3-\frac{1}{x^3}=z^3+3z$. . . . . (15)

Similarly, $x^4+\frac{1}{x^4}=z^4+4z^2+2$; . . . . . (16)

$$x^5-\frac{1}{x^5}=z^5+5z^3+5z; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

$$x^6+\frac{1}{x^6}=z^6+6z^4+9z^2+2; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

. . . . . .

It is seen that each of the expressions for $x^n+\frac{1}{(-x)^n}$ may be derived directly from the two immediately preceding, by multiplying the nearest expression by z and to the product adding the next preceding. These expressions differ from the corresponding ones $\left(\text{for } x^n+\frac{1}{x^n}, \text{ when } z=x+\frac{1}{x}\right)$ in positive-reciprocal equations, only in having the signs of all the terms positive.

8. *The forms assumed by the depressed equations.*—Taking $2m$ successively as 2, 4, 6, . . . in equations (8) and (7) in turn, m alternately odd and even, retaining, of course, only the proper number of terms, equations (10) and (9) give the following:

When $m=1$, from (10), $z+p_m=0$; whence $x^2+p_mx-1=0$, as given directly by (8).

When $m=2$, from (9), $x^2+\frac{1}{x^2}+p_1\left(x-\frac{1}{x}\right)+p_m=0$; whence, by (11) and (14), $z^2+p_1z+p_m+2=0$.

Similarly, $z^3+p_1z^2+(p_2+3)z+2p_1+p_m=0$;

$z^4+p_1z^3+(p_2+4)z+(3p_1+p_3)z+2p_2+p_m+2=0$;

. . . . . .

In equations (9) and (10), then, each binomial may be expressed in terms of $z\left(\text{when } z=x-\frac{1}{x}\right)$, and the resulting equations will be of the mth degree.

9. *To obtain a general expression for* $Z_n = x^n + \frac{1}{(-x)^n}$, *in terms of powers of* $x - \frac{1}{x} = z$ (*equations* (14) . . . (18) . . .).

The sum of the nth powers of the roots of the equation

$$x^3 - px + q = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

has been shown (Todhunter's *Theory of Equations*, Arts. 260, 261) to be

$$S_n = p^n - np^{n-} q + \frac{n(n-3)}{1.2} p^{n-4} q^2 - \ldots$$

$$+ (-1)^r \frac{n(n-r-1) \ldots (n-2r+1)}{\lfloor r} p^{n-2r} q^r + \ldots \quad (20)$$

Suppose $q = -1$, then the quadratic equation (19) is a negative-reciprocal equation, and its roots are of the form a and $\frac{1}{-a}$. Therefore $p = a - \frac{1}{a}$, in this case, and from equation (20), changing the notation, for our purpose, by putting x for a, and z for p, we have

$$Z_n = x^n + \frac{1}{(-x)^n} = z^n + nz^{n-2} + \frac{n(n-3)}{1.2} z^{n-4} +$$

$$\frac{n(n-4)(n-5)}{1.2.3} z^{n-6} + ; \ldots \quad . \quad . \quad (21)$$

it being understood that no powers with negative exponents are included, and the general term being

$$\frac{n(n-r-1)(n-r-2) \ldots (n-2r+1)}{\lfloor r} z^{n-2r}.$$

10.—RECAPITULATION.

The character of the roots in the two classes of negative-reciprocal equations may be stated as follows:

I. In equations of the first class, if a be a root then $-\frac{1}{a}$ must be another root, and there exists no root that does not observe this law. Therefore the roots all occur in pairs of negative reciprocals; as, $a, -\frac{1}{a}$; $b, -\frac{1}{b}$; . . .

II. In the second class of these equations, $\sqrt{-1}$ and $-\sqrt{-1}$ must be two imaginary, isolated roots, while all the remaining roots occur in pairs of negative-reciprocals; as, a, $-\frac{1}{a}$; b, $-\frac{1}{b}$; . . . and in this class the middle term of the equation must be wanting.

Any negative-reciprocal equation of the second class can be reduced to one of the first class, by dividing by x^2+1; and any negative-reciprocal equation of the first class can be depressed to an equation of half the dimensions.

For recognition of the class of a given negative-reciprocal equation.—I. It will be of the first class if the extreme terms have like signs and the exponent of the highest power of x be of the form $4n$; or, if the extreme terms have unlike signs and the greatest exponent be of the form $4n+2$. II. The equation will be of the second class if the extreme terms have unlike signs, the greatest exponent being of the form $4n$; or, have like signs, the form of the greatest exponent being $4n+2$.

11. If the term "recurring equations" had not been given—as another name—to positive-reciprocal equations, it would seem appropriate to make that the inclusive term for the two types of reciprocal equations without discrimination—the "reciprocal equations" of the text-books, and those discussed in this paper.

The statement is hazarded here that positive-reciprocal equations will be met with no oftener than will negative-reciprocal equations—if so often. Yet the latter, so far as known to the writer, have not been noticed as a class.

In a particular direction of investigation of loci, various equations of this type have occurred, requiring solution by the writer. They have been, for the most part, of the fourth or the sixth degree, but also of higher degrees. Immediate recognition of the character of the equation would have been the means of saving much time in finding the roots.

Examples.

I. $y^4+Ay^3-Ay+1=0$; the expression of a law giving a problem met with. Dividing by y^2,

$$y^2+\frac{1}{y^2}+A\left(y-\frac{1}{y}\right)=0. \quad \text{Let } z=y-\frac{1}{y}, \text{ then}$$

$$z^2+2+Az=0;\ z=\tfrac{1}{2}(-A\pm\sqrt{A^2-8}).$$

$$y^2+\tfrac{1}{2}(A\mp\sqrt{A^2-8})y=1,$$

$$y=\frac{1}{4}\left[-(A-\sqrt{A^2-8})\pm\sqrt{2A(A-\sqrt{A^2-8})+8}\right], \text{ and}$$

$$\frac{1}{4}\left[-(A+\sqrt{A^2-8})\pm\sqrt{2A(A+\sqrt{A^2-8})+8}\right].$$

It is seen that if $A<2\sqrt{2}$ the roots are all imaginary; if $A=2\sqrt{2}$ there are two pairs of equal roots, real; if $A>2\sqrt{2}$ the four roots are all real and different.

II. $$Ay^{10}+2(A^3+1)y^9+7Ay^8-8(A^2-1)y^7-26Ay^6+$$
$$(12A^2-20)y^5+26Ay^4-8(A^3-1)y^3-7Ay^2+$$
$$2(A^2+1)y-A=0. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Divide by y^5 and rearrange,

$$A\left(y^5-\frac{1}{y^5}\right)+2(A^3+1)\left(y^4+\frac{1}{y^4}\right)+7A\left(y^3-\frac{1}{y^3}\right)-$$
$$8(A^2-1)\left(y^2+\frac{1}{y^2}\right)-26A\left(y-\frac{1}{y}\right)+12A^2-20=0;$$

assume $z=y-\frac{1}{y}$, and find each binomial in terms of z, from equations (14) to (17), or from (21); then

$$A(z^5+5z^3+5z)+2(A^3+1)(z^4+4z^2+2)+7A(z^3+3z)-$$
$$8(A^3-1)(z^2+2)-26Az+12A^2-20=0; \text{ therefore,}$$
$$Az^5+2(A^2+1)z^4+12Az^3+16z^2=0; \text{ factoring,}$$
$$z^2(Az+2)(z^2+2Az+8)=0. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

From the first factor, $(y^2-1)^2=0$, whence the four roots 1, -1, 1, and -1.

From the second factor, $Az+2=0$, $y^2+\frac{2}{A}y=1$, whence the roots $\frac{-1\pm\sqrt{A^2+1}}{A}$.

From the third factor, $z=-A\pm\sqrt{A^2-8}$, whence

$$y=\frac{1}{2}\left[-(A-\sqrt{A^2-8})\pm\sqrt{2A(A-\sqrt{A^2-8})-4}\right], \quad . \quad (3)$$

$$\text{and } \frac{1}{2}\left[-(A+\sqrt{A^2-8})\pm\sqrt{2A(A+\sqrt{A^2-8})-4}\right]. \quad . \quad (4)$$

It is seen that the roots by (3) and (4) will be real or imaginary under the same conditions as in Example I., the six other roots of equation (1) being real.

III. $y^8+2y^7-3y^6-4y^5+5y^4+4y^3-3y^2-2y+1=0$.

$$\left(y^4+\frac{1}{y^4}\right)+2\left(y^3-\frac{1}{y^3}\right)-3\left(y^2+\frac{1}{y^2}\right)-4\left(y-\frac{1}{y}\right)+5=0;$$

$$z^4+4z^3+2+2(z^3+3z)-3(z^2+2)-4z+5=0;$$

$$z^4+2z^3+z^2+2z+1=0. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Equation (1) presents the singular case of the depressed equation being a reciprocal equation. It is of the first class of the positive type, therefore may be solved by depressing, thus:

$$z^2+\frac{1}{z^2}+2\left(z+\frac{1}{z}\right)+1=0; \text{ assume } w=z+\frac{1}{z},$$

$$\text{then } w^2+2w-1=0; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and, again, we have the singular case of the *second* depressed equation being a reciprocal equation—of the first class of the negative type.

From (2), $w=-1\pm\sqrt{2}$. . . . . (3)

Taking the positive sign of the radical, two values of z are imaginary, $\frac{1}{2}\left[-(1-\sqrt{2})\pm\sqrt{-(1+2\sqrt{2})}\right]$, whence four values of y are imaginary.

Taking the negative sign of the radical in (3),

$$z+\frac{1}{z}=-(1+\sqrt{2}), \text{ whence}$$

$$z=\frac{1}{2}\left[-(1+\sqrt{2})\pm\sqrt{-1+2\sqrt{2}}\right]=y-\frac{1}{y};$$

from which we obtain for the values of y,

$$\frac{-1-\sqrt{2}+\sqrt{-1+2\sqrt{2}}\pm\sqrt{18+4\sqrt{2}-2\sqrt{5+4\sqrt{2}}}}{4},$$

and $\dfrac{-1-\sqrt{2}-\sqrt{-1+2\sqrt{2}}\pm\sqrt{18+4\sqrt{2}+2\sqrt{5+4\sqrt{2}}}}{4}$;

giving four real roots.

IV. $x^6-3x^4+3x^3-1=0$, ... (1)

a negative-reciprocal, and a positive-reciprocal equation of the second class; therefore x^2+1 and x^2-1 are divisors, giving the

four roots $\sqrt{-1}$, $-\sqrt{-1}$, 1, and -1. Dividing equation (1) by x^4-1, we have

$$x^4-3x^2+1=0; \quad \ldots\ldots\ldots \quad (2)$$

which, as a negative-reciprocal, and a positive-reciprocal equation of the first class, may be solved by assuming $z=x-\frac{1}{x}$ or $w=x+\frac{1}{x}$, as well as by treating it as a quadratic in x^2.

Using $z=\pm 1$, $x=\frac{1}{2}(1\pm\sqrt{5})$ and $\frac{1}{2}(-1\pm\sqrt{5})$. . . . (3)

Using $w=\pm\sqrt{5}$, $x=\frac{1}{2}(\sqrt{5}\pm 1)$ and $\frac{1}{2}(-\sqrt{5}\pm 1)$. . . (4)

Solving (2) as a quadratic in x^2, $x=\pm\sqrt{\frac{1}{2}(3\pm\sqrt{5})}$. . . (5)

It is seen that by (5) the roots do not immediately show the simplest forms, as by (3) or (4) when treated as those of either type of reciprocal equations, and grouped as of the form a, $-\frac{1}{a}$; b, $-\frac{1}{b}$, where $b=\frac{1}{a}$; or of the form a, $\frac{1}{a}$; b, $\frac{1}{b}$, where $b=-a$. By (5) the roots directly take the form $\pm a$ and $\pm b$, where $b=\frac{1}{a}$.

V. $y^8-A^2y^6+2(A^2+1)y^4-A^2y^2+1=0$.

A combined positive-reciprocal and negative-reciprocal equation, met with in the solution of a real case of roots required.

Divide by y^4, and rearrange,

$$y^4+\frac{1}{y^4}-A^2\left(y^2+\frac{1}{y^2}\right)+2(A^2+1)=0; \text{ assume } z=y-\frac{1}{y},$$

$$z^4+4z^2+2-A^2(z^2+2)+2(A^2+1)=0;$$

$$z^4-(A^2-4)z^2=-4; \text{ solving as a quadratic in } z^2,$$

$$z^2=\frac{A^2-4\pm A\sqrt{A^2-8}}{2};$$

$$z=\pm\tfrac{1}{2}\sqrt{2A^2-8\pm 2A\sqrt{A^2-8}}=y-\frac{1}{y};$$

whence we find four y's of the same values as those in Example I., and four other values equal numerically to the first four, respectively, but with opposite signs.

To have a recurring equation that combines in one the two types of reciprocal equations, it is obvious that the terms containing odd

powers of the unknown quantity must have the coëfficient zero; that if a be a root, then $-a$ must be another root; that though $\frac{1}{a}$ and $-\frac{1}{a}$, as roots, must satisfy the equation, they may not be additional roots when $a=1$ or $\sqrt{-1}$, though otherwise they will be roots necessary to the forming of the equation.

VI. For comparison, two solutions of a given equation are as follows:

1st solution, cited from *Todhunter's Algebra*, Article 333, (3).—

"Suppose $x^4+3x+1=3x^2+\frac{4}{9}x^2$. . . . . (1)

Transpose $x^4-3x^2+3x+1=\frac{4x^2}{9}$.

Therefore $\left(x^2-\frac{3x}{2}\right)^2-\frac{9x^2}{4}+3x+1=\frac{4x^2}{9}$;

therefore $\left(x^2-\frac{3x}{2}\right)^2-2\left(x^2-\frac{3x}{2}\right)-\frac{x^2}{4}+1=\frac{4x^2}{9}$;

therefore $\left(x^2-\frac{3x}{2}\right)^2-2\left(x^2-\frac{3x}{2}\right)+1=\frac{x^2}{4}+\frac{4x^2}{9}=\frac{25x^2}{36}$.

Extract the square root, then $x^2-\frac{3x}{2}-1=\pm\frac{5x}{6}$.

We have now ordinary quadratics, namely,

$$x^2-\frac{3x}{2}-1=\frac{5x}{6}, \text{ and } x^2-\frac{3x}{2}-1=-\frac{5x}{6}.$$

From the former we shall obtain

$$x=\frac{1}{6}(7\pm\sqrt{85}), \text{ and from the latter } x=\frac{1}{3}(1\pm\sqrt{10}).$$"

2d solution (as a negative reciprocal equation).—Divide the given equation (1) by x^2 and rearrange,

$$x^2+\frac{1}{x^2}-3\left(x-\frac{1}{x}\right)-\frac{4}{9}=0. \quad \text{Let } z=x-\frac{1}{x}, \text{ then}$$

$$z^2-3z+\frac{14}{9}=0; \quad z=\frac{1}{2}\left(3\pm\sqrt{9-\frac{56}{9}=\frac{25}{9}}\right)=\frac{7}{3} \text{ and } \frac{2}{3}.$$

Therefore, $x^2-\frac{7}{3}x=1$, and $x^2-\frac{2}{3}x=1$; from which we obtain $x=\frac{1}{6}(7\pm\sqrt{85})$ and $x=\frac{1}{3}(1\pm\sqrt{10})$.

PROFESSIONAL NOTES.

FRENCH SMALL-ARM SMOKELESS POWDER.

[*Journal of the Royal United Service Institution*, April, 1893.]

According to M. Pouteaux, in his work "La Poudre sans Fumée et les Poudres Anciennes," Dijon, 1892, the smokeless powder used in the ammunition for the French Lebel rifle, Pattern 1886, consists of a mixture of two parts of insoluble to one part of soluble nitro-cotton. He gives the following description of the manufacture: "The above mixture is worked under light runners with 2 per cent. of paraffin and 20 per cent. of water until it becomes thoroughly homogeneous. The very fine pulp thus obtained is pressed between some absorbent material to reduce the amount of moisture to about 5 per cent. The cakes from the press are broken up, and sifted on sieves of 0.6 mm. mesh, to thoroughly divide the material. The powder is dried and then submitted to the action of ether alcohol. The compressed paste is next rolled into sheets 0.5 mm. thick, and afterwards cut into squares the sides of which are 1.5 mm. long." As regards the properties of this powder, M. Pouteaux says that "it gives no smoke on firing and leaves no residue in the barrel, except a few unconsumed grains. If well made, a charge of 2.8 gm. (43.21 gr.) will give a velocity of 625 m. (2050.5 ft.-secs.) with an average pressure of 2400 kilos. on the square centimetre (15¼ tons per square inch) in the French rifle, Pattern 1886. It slows down slightly for the first two months after manufacture, the charge being increased to 2.95 gm. (52.47 gr.), after which it becomes very stable, and it keeps well if the nitro-cottons are pure. The paraffin is added to diminish its sensibility to shock, and to slightly retard the rate of combustion."

EUROPEAN SMALL-BORE RIFLES—THEIR RELATIVE VALUE.

[*United Service Gazette.*]

Professor Hebler, whose exhaustive studies on small-bore rifles well qualify him to impartially assess the value of the weapons now in use, contributes a small article to the *Allgemeine Schweizerische Militär-Zeitung* on the relative value of the various rifles used by the armies of Europe. Since the appearance of his *brochure*, "Das kleinste Kaliber, oder das zukünftige Infanteriegewehr," slight modifications in the rifle itself or in its amunition have, in some instances, altered the efficiency of the weapons; mostly, however, as in the case of the Swiss, Austrian and Bulgarian rifles, to their detriment. Taking the total ballistic perform-

ances, or "goodness," solely into account, the Professor ranges the relative value of military rifles as follows:

Spanish	7.2 mm. (.283 inch)	580
Russian	7.6 mm. (.299 inch)	540
English	7.7 mm. (.303 inch)	521
Swiss	7.5 mm. (.295 inch)	596
Belgian	7.6 mm. (.299 inch)	516
Turkish	7.6 mm. (.299 inch)	516
German	7.9 mm. (.311 inch)	474
Austrian	8.0 mm. (.315 inch)	440
Bulgarian	8.0 mm. (.315 inch)	440
French	8.0 mm. (.315 inch)	433
Danish	8.0 mm. (.315 inch)	411
Portuguese	8.0 mm. (.315 inch)	410
Swedish	8.0 mm. (.315 inch)	393

If the whole ballistic qualities, or "goodness," of the rifles could be relied upon under all circumstances, then the classification shown in the above table would be correct. As a matter of fact, however, several of these military rifles have their weak points, either in connection with the breech action, or the magazine, or in connection with the ammunition. In order, therefore, to ascertain their practical as distinguished from their theoretical "goodness," it becomes necessary, in some cases, to make deductions from their performances under the most favorable conditions. In Professor Hebler's opinion, the English, Swedish, Russian, Austrian, Bulgarian and Swiss rifles are those least to be depended upon, and he consequently makes a deduction of 10 per cent. to allow for their minor defects, whilst he credits all the others with their full ballistic qualities. He thus ranks the rifles into three classes: the first class, including those whose "goodness" exceeds 500; the second class, those whose "goodness" lies between 400 and 500; and the third class, those whose "goodness" falls below 400.

FIRST CLASS.

Spanish	.283 inch	580
Belgian	.299 inch	516
Turkish	.299 inch	516

SECOND CLASS.

Russian	.299 inch	486
German	.311 inch	474
English	.303 inch	469
Swiss	.295 inch	467
French	.315 inch	433
Danish	.315 inch	411
Portuguese	.315 inch	410

THIRD CLASS.

Austrian	.315 inch	396
Bulgarian	.315 inch	396
Swedish	.315 inch	354

From the above it will be seen that the three improved Mausers hold the first places, both from their theoretical and from their practical ballistic qualities; and it appears probable, therefore, that most of the European States, when they decide on re-armament, which they shortly will be obliged to do, will adopt improved Mausers of still smaller calibre.

MECHANICAL DEVICES AND OPERATIONS EMPLOYED IN SEATING A 13-INCH JACKET WHICH STUCK IN THE OPERATION OF BEING SHRUNK ON.

The following description of the method which was recently used with success to seat the jacket of a 13-inch gun, which had stuck in the operation of being shrunk on, was prepared by Ensign A. L. Key, U. S. Navy, and is published by permission of the Bureau of Ordnance.

The theory of the method, as indicated by the Chief of Bureau, was "that, by rapidly cooling the inside of the tube, the average difference of temperature between the tube and jacket could be made considerable, and the inner portion of the tube would contract and draw the outer portion away from the jacket. The surfaces of the tube and jacket in contact would, of course, always be at the same temperature. Experience in this case shows that an actual separation of the tube and jacket furnishes the only certain test as to the time when such a tube and jacket can be assembled. The object in supporting the weight of the tube by the crane, before turning on the water, was to prevent the tube from moving before the maximum separation had taken place; otherwise the galling would have been increased, and it would have been still more difficult to assemble the parts."

This jacket was shrunk on the tube on the 7th of December last. It was placed in the furnace on the morning of December 6 and heated till 4.30 P. M., of that day, when the blast was turned off for the night and again turned on at 8.00 A. M., the 7th.

A temperature of about 600° was maintained in the furnace.

The jacket was given the usual expansion, something more than 0.″07, the shrinkage being 0.″027. The outer surface of the tube and the inner surface of the jacket were smooth, excepting about two feet of the rear end of the latter was slightly rough.

The jacket was lifted from the furnace about 3.00 P. M., the 7th, temperature at top 511, at bottom 558, lowered over the mandrel, which was 0.″02 larger in diameter than the greatest diameter of the tube, and then lowered over the tube. It went on smoothly until about 18″ from its seat when it began to gall. The crane was reversed as soon as possible and the jacket pulled off about 2.″5 when it stuck and brought the tube with it.

The gun was immediately lowered, the set screws in the pit tightened and another attempt made to pull off the jacket, but it again brought the tube with it.

The gun was then allowed to cool.

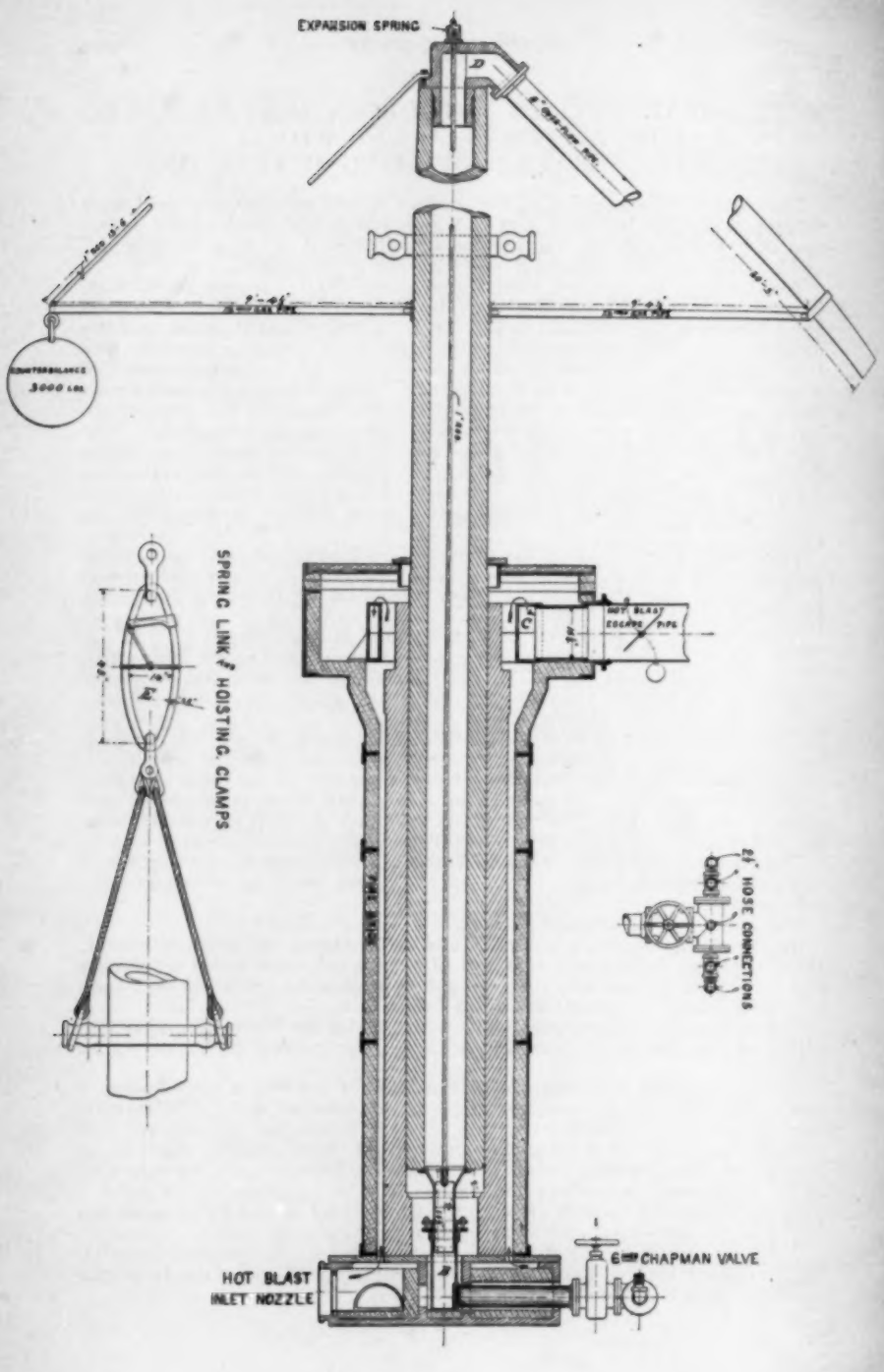
On investigation, the jacket was found to have stuck 12.″16 from its seat, there were two galls at the rear end of the jacket, each about 0.″5 wide and 0.″025 deep, and two galls on the tube forward of the jacket, each 2.″5 long, about 0.″2 wide and 0.″02 deep.

The following preparations were made under the direction and supervision of Captain W. T. Sampson, U. S. N., for getting the jacket in its place:

The gun was put in a lathe, the forward face of the jacket turned off 0.″1 and a fillet turned on the inner edge of the forward face. The furnace was made ready to receive the gun, breech down, the top altered, and asbestos packing used to make an air-tight joint around the jacket. January 16, the gun was placed in the furnace, breech down, the rear face of the jacket resting on the iron bottom.

Water connection was made with the breech end of the tube, as shown in the accompanying sketch, marked *A* (not shown).

Asbestos packing was used at the joint between the pipe and the tube. Water connection for the overflow pipe at the upper end of the tube was made, as shown in the sketch, marked *D*.


EXPANSION SPRING
COUNTERBALANCE
3000 Lbs.
SPRING LINK & HOISTING CLAMPS
HOT BLAST
COUPLING PIPE
2½" HOSE CONNECTIONS
6" CHAPMAN VALVE
HOT BLAST
INLET NOZZLE

The overflow pipe was counter-balanced by a weight of 3000 lbs., as shown in the sketch. A long wooden arm, not shown in sketch, was attached to the tube about four feet above the jacket.

It rested on a knife edge near the tube, so that the outer end exaggerated any vertical movement of the tube in proportion of about 25 to 1. A spring link *E* was made, tested and marked so that the pointer would indicate when it bore a weight of 33,000, 42,000 and 57,000 lbs.

The weights of tube and jacket were 44,000 and 38,000 lbs., respectively. At 8.00 A. M., January 19, started to heat furnace and maintained a temperature between 600° and 650° until 2.30 P. M. the 21st, when preparations were made for turning the water through the tube. A piece of lead, melting point 600°, was lowered by a wire to the bottom of the tube, where it melted.

The crane was attached to the clamp on the tube and a gradual strain put upon it until the pointer showed a strain of 57,000 lbs.

At 2.45 the water was turned on full head through the tube and the pointer in the spring link closely watched to see if it changed position, which would indicate that the tube in rapidly cooling had contracted away from the hot jacket until disengaged from it, relieving the crane of about one third of the strain.

The pointer did not change its position, though an opening of about 0.″03 was observed between the tube and forward end of jacket, but on one side only, the tube not standing strictly vertical.

After the water had been going through the tube about thirty minutes the crane was relieved of its strain, but the tube did not move. After several more attempts, the experiment was finally abandoned for the afternoon. The water was turned off and the heat turned on the furnace, maintained during the night and the next day until about 3.30 P. M., when the water was again turned on the tube, the crane taking a weight of 57,000 lbs., as before.

After the water had been going through the tube for twenty-three minutes, though there had been no movement of the pointer in the spring link, the crane was relieved of the strain, and the tube went down 4.″62, leaving it 7.″54 from the shoulder of the jacket.

The cooling of the tube was continued and further attempts made by taking and relieving the strain on the crane, but without success. The gun was allowed to cool and was taken from the furnace January 25, placed in a lathe, and the rear end of the jacket faced off so as to make the tube stand vertical.

It was found in the foregoing experiments that the furnace had not equally heated all parts of the jacket so that the pipe *C* with openings on the upper side was cast and placed in the furnace to force the hot air to distribute itself equally on all sides of the jacket. Before this arrangement the draft to the chimney was on one side of the furnace. As the slip joint *A* had leaked considerably when the tube went down, and as the pipe and packing prevented the extreme lower end of the tube from being cooled as rapidly as the other portions, the water connection, with the bottom of the tube, was changed, as shown by the sketch marked *B*.

Asbestos packing was used at the juncture of pipe and tube, and a stuffing box and piston packing used for the slip joint between the two pipes.

The long one inch rod through the centre of the tube, with a spring at the top to allow for expansion and contraction, served to keep both water connections in place. The top of the furnace was raised a few inches to allow a more thorough heating around the upper end of the jacket. The other conditions were the same as in the previous experiments. The gun was placed in the furnace, breech down, the tube standing vertical. February 17, the hot blast was turned on and for seventy-two hours a temperature between 600° and 700° was maintained.

At 2.00 P. M., February 21, the crane was attached to the tube and a strain of 57,000 lbs. placed upon it; the hot blast was turned off, the water turned on full head and after thirteen minutes, a slight opening showing between the upper end of the jacket and tube, though there was no movement of the pointer in the spring link, the crane was relieved of its strain and the tube went to its seat.

In the foregoing experiments, when the water was turned on, there was a slight ebullition of steam for about fifteen seconds, after which the temperature of the water was raised only between 5° and 10°, and rapidly fell until the difference of temperature before entering and after leaving tube was less than 1°.

A NEW SYSTEM OF COMPASS CARDS OF SMALL WEIGHT.

By Dr. P. J. Kaiser, Chief Inspector of Nautical Instruments of the Netherlands Navy.

[Translated from the *Revue Maritime et Coloniale*, February, 1893.]

In order that compass cards may be used with confidence on board ship, they must satisfy conditions, both theoretical and practical, which have only been known during the past few years.

The object of the card is to indicate magnetic north with accuracy, under whatever conditions the ship may be placed. Unfortunately, these conditions are often so unfavorable that most known forms of compasses fail to accomplish this end. Theoretical research on shore and practical experiments on board ship have taught that, in the construction of compass cards, the following conditions must be fulfilled:

1. The quotient obtained by dividing the magnetic moment of the card by its weight should be as great as possible.

2. The quotient obtained by dividing the moment of inertia of the card about a central axis perpendicular to its plane by its weight should be as great as possible.

3. The card should be as light as possible.

The existing light cards satisfy the two last conditions well enough, but by the sacrifice of directive force. It is evident that a compass card having a very small directive force will be easily disturbed in its indications by the friction on its pivot and against the surrounding air in the bowl, and by still other causes. This fault is the more troublesome on board iron ships in situations where the earth's horizontal force is in great part neutralized by the induced magnetism of the neighboring soft iron. On board iron ships, therefore, it is desirable to use cards of great magnetic moment.

To overcome the defects of the existing light-weight compass cards, I have designed a card which, to my mind, satisfies the three conditions above mentioned, and which has, moreover, the advantage of being very inexpensive.

A piece of silk on which a compass rose is lithographed is secured around its edges between two rings, each of which is made partly of steel and partly of copper ribbon of the same size.

If this is properly done, a perfectly circular hoop covered with silk is the result. The steel parts, after having been magnetized, form the actual magnetic needles of the card. The copper parts should be of such length that the poles of the magnets of the exterior ring are separated by an angle of 26°, and those of the interior ring by an angle of 96°. The north and south line of the card should naturally bisect the angles

between the poles of the circular magnets exactly. In the centre of the card is a cap fitted with a sapphire. The card is magnetized in the ordinary way by the aid of an artificial magnet.

After magnetization, the card has in each of the two rings two north and two south poles, separated as mentioned above; there are, therefore, eight magnetic poles so placed that Evans' theory regarding magnetic needles of great length is completely satisfied.

If the directions laid down by Evans are departed from, it is well known that the correction of large quadrantal deviations gives rise to sextantal, octantal and decental deviations, if soft iron is used at small distances from the compass, which is a necessity because the quantity used would and should be somewhat limited.

It is unnecessary to say that, however simple the construction of the card, as described above, may seem, practice is required to make it properly. For example, the silk disc should not be stretched, for the cloth shrinks under the influence of heat, and the rings will be deformed if the silk has not sufficient play. Again, the rings must be placed a little below the point of rotation of the card in order that the moments of inertia with reference to all axes may be the same. Remembering that the specific gravity of copper, even when rolled under heavy pressure, does not differ much from that of steel, it will readily be seen that, as a consequence of the construction of the card, its moments of inertia about any axis in the plane of the card must be equal.

In order to render the silk less sensible to the influence of the moisture and changes of temperature, it is coated with paraffine and then treated with a preparation which restores to the too transparent coated silk a dead white, non-transparent appearance.

The following table, the data for which are taken from the work of the *Deutsche Seewarte*, Hamburg, *Der Kompas an Bord* (page 43), gives a comparison of these cards with those of Thomson, Hechelman, and others, as far as regards the three conditions mentioned above:

System.	*Maker.*	*Diameter in millimetres.*	*Weight in grams.*	*Magnetic moment divided by weight.*	*Moment of inertia divided by weight.*	*Time of one oscillation in seconds.*
Thomson.	White.	254	12.0	0.157	10.38	19.1
Thomson.	Harry.	250	13.4	0.232	9.65	15.2
Thomson-Ludolf.	Ludolf.	252	20.5	0.097	7.95	21.2
Hechelman.	Hechelman.	235	42.6	0.166	10.97	19.2
Hechelman-Thompson.	Hechelman.	255	16.5	0.273	13.57	16.5
Dr. P. J. Kaiser.	Olland.	246	16.5	0.476	13.27	12.4

It will be noted that these cards exceed in directive force, and that their moment of inertia divided by their weight is nearly equal to that of the greatest while the weight itself is very small.

[NOTE BY TRANSLATOR.—Dr. Kaiser continues his article by comparing the cost of his card with that of cards made on other designs, claiming that the latter are, at least, twice as expensive; and gives extracts from a number of favorable reports made by different sea captains upon the use of his card under different circumstances. Captain Harten, of the Netherlands steamer Prinses Amalia, reported that he had replaced the compass card in use on the forward bridge by a Kaiser card while the ice machine was in operation, and the oscillations, which had ranged from 6 to 8 points, were at once reduced to ¼ to ½ of a point. The card has been adopted in the navy of Holland, and has been found eminently satisfactory, notably on board the first-class torpedo-boat Habang. Dr. Kaiser considers that the satisfactory use of his card on a torpedo-boat is an excellent test of its merits, and with reason.]

PHOTOGRAPHING FLYING BULLETS.

[*United States Gazette*, May 6, 1893.]

At the Royal United Service Institution on Friday, April 28, Sir Frederick Bramwell presiding, Professor C. V. Boys, of the Royal College of Science, gave a lecture, illustrated by photographs and experiments, on "The Photography of Flying Bullets by the Light of the Electric Spark." The lecture was of a highly technical character, and consisted largely of explanations and elucidations of the numerous photographs, nearly thirty, in which the experiments were recorded. Professor Boys alluded to the various methods of obtaining photographs of moving objects traveling at a high rate of speed, such as the rapid-shutter system, in which the eye of the camera is only allowed to see through a small aperture for a moment, and the magnesium flash. But neither of those sufficed to give a sharp picture of a bullet *en route* at an ordinary rate of speed. Nor would the electric spark be of much use in photographing the bullet of a magazine rifle passing along at the rate of about 2100 feet in a second, or about 1400 miles an hour. The result was found to be a mere blur, the spark lasting so long that the bullet was actually able to travel half an inch or so while the illumination lasted. Mr. Boys, therefore, set himself the task of manufacturing an electric spark which, while it gave light enough to act on the plate, lasted so short a time that even a rifle bullet could not move an appreciable distance during the time it was in existence. This he accomplished by using a revolving mirror made of hardened steel, and capable of running round at the rate of 1000 turns a second. The light from the spark was focused by the mirror upon a photographic plate while revolving at the rate mentioned, equivalent to about 160,000 miles per hour, or 200 times faster than the speed of a Maritini-Henry bullet. In this way, as Professor Boys illustratrated in detail, perfectly sharp photographs of flying bullets were obtained. Professor Mach, of Prague, first accomplished the feat by means of a specially contrived electrical apparatus, and succeeded in photographing the air waves caused by the bullet in its flight. Professor Boys believes his apparatus to be of a simpler kind than that adopted by Professor Mach. A photograph of the apparatus was shown, but a mere description of it would be illusory and uninteresting. One of the photographs showed a bullet just as it had left a Maritini-Henry rifle. It appeared perfectly sharp, and there was no sign of any movement, so far as the bullet itself was concerned, but there were distinct evidences of the presence of air waves. These waves were much more conspicuous in another photograph of a bullet from a magazine rifle going along at the rate of 2000 feet per second. The waves were more inclined to a vertical inclination than the others, and the lecturer gave an elaborate explanation of the reason why the inclination of the waves varied with the rate of speed. These waves, revealed by photography, have a very important effect on the flight of projectiles, and the illustrations exhibited created much interest. In order to test the analogy between air waves and water waves, and to see whether the former could impede the progress of a bullet, in the same manner, though in different degree, as the latter affect the motion of a ship, the lecturer arranged three reflecting surfaces of sheet copper, and photographed the result of the air waves striking against them. From these experiments he concluded that the reflection or non-reflection of air waves produced by a passing bullet when meeting with a solid body might bring about important results. Professor Boys also described experiments in which he sought to ascertain what proportion of the velocity of a bullet was given to it after it had left the barrel, and the action of a choke-bore upon a charge of shot. Another very

interesting series of experiments was detailed, showing the process of a bullet piercing a glass plate from a first shock, step by step, until the bullet had escaped out of the midst of the disaster and confusion it had created. The lecturer concluded his task amidst the hearty applause of his audience.

Some interrogatory remarks were made by Colonel C. H. Scott, Mr. Rigby, Colonel Fosberry, Captain Straker and Captain Acland; and Sir F. Bramwell, observing that such experiments would, even but a few years ago, have been regarded as impossible, tendered the thanks of the meeting to Professor Boys for his unique lecture.

ENGINE-ROOM ARTIFICERS.

[*United Service Gazette*, April 1, 1883.]

The anomalous position held by the engine-room artificers and the undoubted grievances under which the class labors have frequently been referred to in the columns of the *United Service Gazette*. The concessions now asked for are of so reasonable a nature we cannot think but that they will be granted in the near future. A fresh statement of their claims to the following effect has been circulated by the engine-room artificers amongst members of Parliament and others. It is commendable for its moderation:

The engine-room artificers of the Royal navy, it states, are a class of mechanics privately trained in the necessary respective engineering trades at their own parents' expense on shore, and when fully qualified as workmen, they are entered in the Royal navy to execute the skilled mechanical work in the engine and boiler-rooms of Her Majesty's ships of war; in addition to which they have also now to perform similar duties to that of junior engineers, such as keeping watch in either engine or boiler-room. In fact, they are not even retained in the Royal navy, or receive any rise of pay, until they obtain from their own immediate superiors, the engineer officers, certificates (approved by the captain of their ship) of competency in those particular duties.

The class was introduced into the Royal navy as an experiment by an Admiralty Order in Council, March 28, 1868, and proving a success, the Lords of the Admiralty under different administrations permanently established it in the naval service of the country, and very largely increased its numbers, with a corresponding decrease in those of the junior engineers, and artificers are now sent to ships in lieu of such commissioned officers.

Since the establishment of this class everything connected with engineering science has gradually become more complicated, and of necessity requiring greater skill and attention on their part, and the recent reduction of mechanical skill in the engine-room complements of Her Majesty's ships has placed more arduous labor and greater responsibilities than ever upon the engine-room artificers. A large number are now placed in sole charge of the machinery of small ships, torpedo-boats, etc., with all the men in the engine department under their management and control. They have also to keep the stores and necessary books connected therewith, and yet their status is still but that of a petty-officer—a similar rank to that of many of the men who work under their instructions. In the interest and for the well-being of the naval service, and to carry out our necessary discipline, they ask very humbly that chief engine-room artificers be placed in an equivalent rank with warrant officers, and that engine-room artificers with six years' service should rank with but after warrant officers, with their privileges, and be entitled engineer artificers. An

engine-room artificer relieves an engineer officer in his watch and performs similar duties; the latter is a commissioned officer, whilst the engine-room artificer and leading stokers who work under his orders are both petty officers. The rank of warrant officer would be a sort of intermediate one for them between the before-named commissioned officer and ordinary petty-officer.

They also ask that their mess place should be greatly improved, and invariably carried from deck to deck. As a general rule it is on the lower deck, a bulkhead breast high, in some cases of iron plates, and not the least isolated, but often in very exposed places. They also request that in all ships a separate wash place should be provided for the engine-room artificers, to prevent as far as it can be carried out, their association with the stokers. This would greatly add to the discipline of the navy and stop a great deal of unpleasantness and a grievance to which they are at present subjected. . . . . .

It is pointed out that any proposal to increase the number of chief engine-room artificers is not of the least advantage to the class in general, as it is an impossibility for the majority of them even to obtain this rating; if it were possible, it would not in the slightest remove the disability under which they as a class of naval mechanics labor, and would not be of any advantage whatever to any man except as regards his obtaining a little more pay. His position on board a ship — that of a chief petty-officer — is precisely the same as it was before he received the higher rating.

In asking for their position to be improved from chief petty-officers to that of warrant officers, with similar privileges, the engine-room artificers are fully aware of the difficulties that beset such an arrangement and change, and of the plea that the limited accommodation for cabins on board Her Majesty's ships prevents such a step being taken on their behalf; but they would most humbly draw attention to the following table, which shows their exceptionable position compared with that held by other departments in the same vessel in which they may be serving.

Gunnery Department.	*Navigating Department.*	*Carpentering Department.*	*Engineering Department.*
Gunnery Lieutenant, Commissioned Officer.	Staff Commander, Commissioned Officer.	Commander, Commissioned Officer.	Chief Engineer or Engineer, Commissioned Officer.
Chief Gunner, Rank with Sub-Lieutenant.	Chief Boatswain, Rank with Sub-Lieutenant.	Chief Carpenter, Rank with Sub-Lieutenant.	
Gunner, Warrant Officer.	Boatswain, Warrant Officer.	Carpenter, Warrant Officer.	
Chief Gunner's Mate, Chief Petty Officer.	Chief Boatwain's Mate, Chief Petty Officer.	Chief Carpenter's Mate, Chief Petty Officer.	Chief Engine-room Artificer, Chief Petty Officer.

From the above it will be seen that there are two intermediate steps between the commissioned or ward-room officers in all departments except the engineering, where there is no gradation of rank between a commissioned officer and a chief petty officer. In some cases, even in large vessels, the only engineer officer on board has fallen sick, and then the whole responsibility and onerous duties of the engineering department have fallen on the senior engine-room artificer. All persons conversant with the routine of the Royal navy, or duties on board a man-of war, well know the great chasm between the commissioned officer and petty officer, and the engine-room artificers only ask for the intermediate or similar rank of warrant officer in the engineering department. In point of accommodation they do not ask for a separate cabin for each engine-room artificer, similar to the gunner, boatswain or carpenter; far from it, such is not

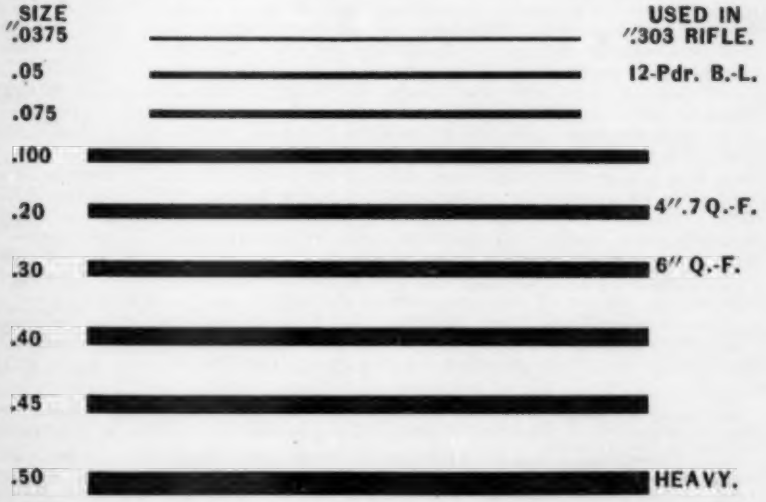
their wish or desire; but they humbly ask for an enclosed mess berth, carried from deck to deck, instead of the present arrangement now fitted for them, about three or four feet high. The argument has been used that the mess berth, if carried to the deck, would interfere with the ventilation of the ship. This remark will apply to every cabin in the vessel, so that one more will not make any material difference in that respect. They further represent that in their present so-named mess berth fire hoses are, in some cases, stowed over their heads and shot under their feet, and that often the seamen hang their hammocks and sleep over their heads. When the ship is under steam the engine-room artificers require a resting place between their watches; this is now denied them by the present mess berth. In all cases, a bath and washing arrangements separate from the stokers should be fitted. The pensions of the class are not at all in proportion to their pay, as compared with other classes. They ask to have them increased to £3 15s. per annum for each year's service as chief engine-room artificer, and £3 10s. for each year as engine-room artificer. This would not effect the estimates (to any extent) for some years to come.

CORDITE.

[Reprinted, by permission, from the lecture of Lieut.-Col. F. W. J. Barker, in the *Proceedings of the Royal Artillery Institution*, May, 1893.]

Cordite. { Nitro-Glycerine, 58.
Gun-cotton, 37.
Mineral Jelly, 5.

Comparative Table Showing Dimensions of Cordite at Present Used.



The thicker cordite, size 20 and upwards, is cut into lengths of 14 inches, and used in bundles of the required weight for the charge.

Cordite for field guns is 11 inches long, and the S. A. rifle charge is made up of 60 strands, or threads, of suitable length for the cartridge.

We have now examined the outlines of the methods employed in the manufacture of modern powders, and some of the processes which have been adopted to render them reliable propellants with the various guns in our service. The next step, or rather leap, in this manufacture to be considered is the introduction of smokeless propellants. We are all aware how, for many years, this has been the ambition of the artillerist and the study of the chemist. It is hardly necessary to remind Officers of the Royal Artillery of the failures in this direction, which, for more than three decades, frustrated the efforts of those who tried to obtain a smokeless powder for rifled guns and small-arms. Gun-cotton in every form, picric acid in various conditions, and many tri-nitro and di-nitro compounds were experimented with, confidently at first, then hopefully, and apparently finally abandoned in the face of what seemed to be insurmountable difficulties. At last, however, a sudden impetus was given to the whole question, about seven years ago, by recent discoveries in chemistry, and by the supreme importance which the introduction of quick-firing guns and magazine rifles gave to the production of a powder which would not, by its smoke, utterly neutralize the benefits to be obtained by rapidity of fire. Most of us remember that many years ago smokeless powder was considered to be a possibility within reach, when the character of gun-cotton was first recognized, and it was thought that this substance might be utilized by being kept under control or "tamed" by some retarding agent. To the unscientific but practical man this seemed a matter not difficult to accomplish. On the one hand, we have a violent explosive of good gas producing powers and almost unlimited energy; on the other, an almost boundless range of dilutants, retarding agents, or "tamers," which, in greater or less quantities, should at any rate bring the violence of the explosion of gun-cotton to the same level as that of gunpowder. Here then, at first, was the problem to solve: To use with gun cotton such a retarding agent as will "tame" the explosive, make it safe to handle, store and use, and at the same time leave it with sufficient energy for use in modern guns and rifles with certainty and regularity of propulsion. This problem, simple as it appears, baffled, for decades after gun-cotton was known, the energies and knowledge of the most scientific artillerists and chemists; and it is only within the last few years that any real approach to success has been made, and this success has been chiefly due to the use in the right direction of one of the properties which gun-cotton exhibits, namely its solubility in acetone.* The solubility of gun-cotton in acetone has been known for a considerable time; but how to utilize this property for artillery purposes has only recently been discovered, and is still the subject of careful investigation. Again, in January, 1888, Messrs. Nobel & Co. registered a patent of the discovery that nitro-cellulose could be mixed with nitro glycerine and that the two so combined, with or without the addition of a retarding agent, form a substance which can be relied upon for ballistic purposes. This, with other discoveries made about the same time, may be considered as practically the starting point for the most valuable of the smokeless

*Acetone, or "dimethyl-ketone," $CH_3CO\,CH_3$, or "pyro-acetic spirit," is obtained among the products of distillation of wood, and may be prepared by distilling the acetate of lead calcium or barium.

The crude distillate is shaken with a saturated solution of hydrosodium sulphate, which combines with acetone to form a crystalline compound $(CH_3)_2\,CO.HNa\,SO_3$. This is freed from the mother liquor and distilled with sodium carbonate, when acetone distils over mixed with water, which is removed by fuzed calcium chloride.

Acetone is a colorless, fragrant liquid, Sp. gr. 0.81, and boiling at 56.3 C. = 133.3 Fahr. It is inflammable, burning with a luminous flame. It mixes with water, alcohol and ether. —*Bloxam's Chemistry.*

powders, and those most largely used in the services, both in England and on the continent of Europe.

As cordite is composed of two "high explosives," gun-cotton and nitro-glycerine, the means adopted for converting them into a reliable propellant have now to be considered.

"High explosives" have all, more or less, the characteristics to which they owe their title. These are, great sensitiveness under certain conditions, and liability to violent explosiveness or detonation in their ordinary or "untamed" condition.

One can well understand that none of these substances untamed are suitable for use with arms of precision. Under certain circumstances they might give fair shooting and satisfactory results; and under others their violence might be productive of the most serious consequences. A reliable retarding or "taming" agent was therefore absolutely necessary, and by using a solvent, such as acetone, and reducing gun-cotton to a plastic mass and then adding an inert or "slowing" substance, either a resin, grease, or other material, this violent explosive has been tamed down to any degree of rapidity of combustion required.

Gun-cotton has, however, one serious drawback, and that is that even with the highest degree of explosiveness which can be permitted for safety, it does not produce a satisfactory proportion of permanent gases during combustion, and the pressures developed are too high in comparison for the velocities obtained with the projectiles. We are therefore obliged to introduce some other ingredient which, while not producing smoke, will evolve the necessary gases for propulsion of the projectile, without increasing the rapidity of combustion or involving the risk of detonation. All manner of inert substances have been tried for this purpose with more or less success, but none as yet have been perfectly satisfactory. I may say, however, that a near approach to a gun-cotton smokeless powder was made at Waltham Abbey some years ago, when a grained powder was produced which, while smokeless, gave the best shooting obtained up to that time. Just at this period, however, the discoveries previously referred to were developed, namely, that an *active* agent could be used with gun-cotton, and nitro-glycerine combinations rapidly took the field.

The strange anomaly of two of the most violent explosives known, nitro-glycerine and gun-cotton, when combined in nearly equal proportions, producing a moderate explosive under control was, as I have already said, the starting point of a new era in smokeless powders. Nitro-glycerine is, as we know, about the most violent explosive yet discovered, gun-cotton is also noted in the list of "high explosives." Both when separate are very sensitive and easily detonated; but when combined they burn with great regularity.

I have now briefly mentioned the two great classes of smokeless powders; first gun cotton and its kindred chemical compositions with a retarding agent, and, second, gun-cotton combined with nitro-glycerine where nitro-glycerine takes the place of the retarding agent which was formerly used with gun-cotton. The first has not been so successful for the reasons already given, while the latter (gun-cotton with nitro-glycerine) gives most excellent ballistics but very high temperatures. The excessively high temperature which is produced by the use of nitro-glycerine has contributed towards the continuation of investigations on the Continent, as to the possibility of obtaining a gun-cotton or other smokeless powder; but hitherto we have not heard of any marked success.

I think that we are now in a position to discuss the manufacture of the smokeless powder, cordite, which promises so favorably, and which has been made so successfully in large quantities for over a year at Waltham Abbey.

Cordite is a smokeless propellant of the combined nitro-cellulose (or

gun-cotton) and nitro-glycerine type. Its composition was determined by a committee (The Explosives Committee) of most distinguished chemists, with Sir Frederick Abel as president. They decided that the proportion of the ingredients should be gun-cotton, 37 per cent.; nitro-glycerine, 58 per cent.; and mineral jelly, 5 per cent. The gun-cotton is first dried (in the form of 9-ounce primers) down to about 1 per cent. moisture. Then a portion (27¾ lbs.) is placed in a brass-lined box, and 43¼ lbs. nitro-glycerine are carefully poured over it. These ingredients are then carefully mixed by hand and taken to the incorporating machines, and the whole is brought into a gelatinous condition by the addition of about 15$\frac{10}{16}$ lbs. of acetone, which is poured over the charge in the incorporating machine, and worked up into a kind of dough. 3¾ lbs. of "mineral jelly" * are afterwards added, and the material is incorporated or mixed for seven hours. When it has been sufficiently incorporated and is ready, the charge is taken to the press house where it is squeezed in a cylinder, one end of which has a small hole of the required size for the cordite, which is sqirted through by means of a plunger or piston pressing on the other end of the cylinder. The cylinder is filled with composition and the plunger pushes or squirts the soft material in the form of cord or string of the thickness required. The sizes are .0375 in., which is used for the rifle, up to .5 in., which has been experimentally used with a heavy B.-L. gun with satisfactory results. This string is wound on reels for the smaller, or cut into lengths for the larger natures. It is then placed in a stove and is dried, to get rid of the acetone, at 100 degrees Fahr., from three to nine days, according to the thickness of the cordite. It is afterwards blended in the rifle cordite, by taking the production of ten presses which are on "one strand" reels and winding these on to one "ten strand" reel. Then the cordite on six "ten strand" reels is wound on to one drum, which make up a rope or cord of 60 strands, which in short lengths form the 30½ grain charge of the magazine rifle. The larger natures of cordite are blended on the same principles as gunpowder. Cordite has proved itself to be very safe to manufacture in its later stages, *i. e.*, *after* incorporation, and although we have had slight ignitions, I am glad to say that no explosion of any consequence has occurred.

Having now briefly sketched the outline of the manufacture of cordite, we will turn to what is doubtless the more interesting portion of the subject to practical gunners, namely, what are its shooting properties, its keeping qualities, and what is the effect of using it in the guns and small-arms with which it is employed.

Shooting Qualities.

First, as to its shooting qualities, we can best judge of them by actual results obtained, and by comparison with our old friend black powder in the same weapon. These results, which are shown in the table before us, speak for themselves. I owe the latest results to the kindness of the Director-General, Dr. Anderson, and to our friends at Waltham Abbey. I have here sketched a comparative table, showing the results obtained by black powder and smokeless powder. The black powder is in Roman type and smokeless powder in black type, and I think that, without any further demonstration, we can see for ourselves the great advantages to be obtained if the smokeless powder always does what the table before us indicates. First we have 30 grains of the smokeless powder giving a 2000 feet velocity, as against 70 grains of the best of the

* Mineral jelly (vaseline) is the liquid which distils over from petroleum at temperatures above 200 C. It is a hydrocarbon, richer in carbon than petroleum, and boils at about 278 C. Formula $C_{16}H_{34}$.

modern black powders giving 1830 feet velocity, + or — 40. Then, in the field gun (which most of us here are interested in) one pound and half an ounce of smokeless powder (cordite) must give, as a condition of accept-

Comparative Results.

Cordite and Black.

Nature.	Charge.	Velocity.	Pressure.
Magazine Rifle.	70 grs.	1830 ± 40	18
do.	**30 grs.**	**2000 ± 40**	**15**
12-pdr. B.-L.	4 lbs.	1710 ± 20	15
do.	**1 lb. 0½ oz.**	**1710 ± 20**	**15**
4.7-in Q.-F.	12 lbs.	1830 ± 30	16 to 17.6
do.	**5 lbs. 7 ozs.**	**2145 ± 25**	**15**
6-in. Q.-F.	29 lbs. 12 ozs.	1890	15
do.	**14 lbs. 3 ozs.**	**2274**	**15.2**

ance for service, 1710 feet + or — 20, as compared with 4 lbs. S. P. (selected pebble), which gives 1710 f. s. Then quick-firing gun, the 4.7-inch, gives, with 12 lbs. black pebble, 1830 feet + or — 30, while with 5 lbs. 7 ozs. of smokeless powder it gives 2145 feet + or — 25. I think those results speak for themselves. Then again, in the 6-inch gun, 29 lbs. 12 ozs. of black powder giving 1890 feet muzzle velocity with 15 tons pressure. The results in the table are based upon actual shooting, and the conditions of acceptance are framed upon practical experience, and these conditions must be complied with by all powders before they are allowed to pass into the service. It may here be interesting to quote some of the actual shooting within the last few months of our own experience, and for these, the latest results, I have again to thank our friends at Waltham Abbey, and also the Director-General, who has kindly permitted me to have them. With lot 8, size 5 * (that is, field gun size) in the 12-pdr., 1 lb. 0½ oz. charge, from the actual results fired in July last we obtained 1732 feet as the muzzle velocity with 13.84 pressure. The results which were forwarded to me last month were 1726 feet velocity with the same lot, and 13.45 pressure. The temperature of the air when the firing took place in December being quite sufficient to account for the slightly lower results as compared with those obtained in July. It is easy to understand the favorable impression that results of this nature make upon those who watch them carefully. Then there are other difficulties which had to be contended with, and one was technically termed "sweating," which frequently causes strained relations between employers and employed (or unemployed?). Our "sweating," however, had nothing to do with workmen, but it was a curious propensity which some batches of cordite exhibited in exuding the nitro-glycerine on the

*Size 5, lot 8, fired at Woolwich, 7 July, 1892, in 12-pdr. B.-L. gun, charge 1 lb. 0½ oz.

M. V.	Mean.	Pressure.	Mean.
1734		13.3	
1731		14.2	
1733	1732	14.1	13.84
1733		13.8	
1728		13.8	

surface. There are various causes which produce this exudation, one of which is water in the nitro-glycerine before incorporation; there are also several others which we need not enter into here, but I believe that the difficulty has been completely overcome by arrangements during manufacture.

Climatic Trials.

Secondly, as to climatic trials or keeping qualities. Climatic trials have been carried out all over the world, and they have so far proved eminently satisfactory. The arctic cold of the winter in Canada with the temperature below zero, and the tropical heat of India have as yet failed to shake the stability of the composition, or abnormally injure its shooting properties. The Director General kindly wrote to me the other day and said that cordite returned from Canada has been analyzed, and has been quite unchanged. I have myself had under my own observation 100 lbs. in an open case, exposed, in an open porch, to all the vicissitudes of a Waltham winter—snow and rain—and also to an English summer—rain without the snow—and the results again showed that there was hardly any perceptible difference in shooting due to this severe test. If our old friend pebble or prismatic powder had half this ill-treatment one would have wished for a sea range, and a clear one, to fire over, and should certainly have protested against ordinary proof within twelve miles of London.

Thirdly, the effect on the weapon.* This may perhaps, and indeed is likely to prove the weakest point in the use of cordite under certain conditions. The small-arm magazine rifle undoubtedly suffers in the bore from the great heat evolved and the high velocity imparted to the projectile. On the other hand, we have at Waltham Abbey a 4.7-inch quick-firing gun which has fired, up to September last, over 40 rounds of black and 249 rounds of cordite, and yet the bore shows no abnormal erosion or scoring. We have also a 12-pdr. B.-L. constantly used, up to the same date, for firing pebble and cordite, and the bore is as smooth as could be expected.

In conclusion, we must all remember that, although smokeless powders have developed so rapidly, and have shown such great suitability for the guns with which they have been used, they are still in their infancy, and have not yet been subjected, on any large scale, to the stress of active operations in the field, engagements at sea, or lengthened storage in average magazines. So far as our experience goes, however, the results have been eminently satisfactory with our own smokeless powder, Cordite.

*Since writing the above, the lecturer has been informed that in the .303 magazine rifle this difficulty has been almost overcome by the use of a suitable wad.

BOOK NOTICES.

INDEX TO THE LITERATURE OF EXPLOSIVES, PART II. By Charles E. Munroe, late Chemist to the Torpedo Corps, U. S. Navy. Deutsch Lithographing and Printing Co., Baltimore, 1893. Subscription price, in paper, $1.00.

In Part II. of his Index, Professor Munroe carries on his valuable reference list of articles bearing upon explosives that have appeared since the publication of Part I. in 1886, and in addition gives references to Dingler's Polytechnisches Journal, Nicholson's Journal of Natural Philosophy, Edinburg Journal of Science, Popular Science Monthly, Proceedings American Chemical Society, and Brande's Journal of Science and Arts.

His researches have been carried through nearly one thousand volumes, and include the following named periodicals, besides those mentioned above: American Journal of Arts and Sciences, Philosophical Transactions of the Royal Society, PROCEEDINGS OF THE U. S. NAVAL INSTITUTE, Revue d'Artillerie, Journal of the Royal United Service Institution, and Reports of H. M. Inspectors of Explosives. The two parts of the Index are believed to be complete from the date of first issue up to and through the year 1890 for each of the periodicals mentioned.

The Index admirably supplements the author's "Notes on the Literature of Explosives," which have been published from time to time in these pages, and is an invaluable reference list for military men and students of explosives in general. H. S. K.

ELECTRO-CHEMICAL EFFECTS DUE TO MAGNETIZATION. A dissertation presented to the Board of University Studies of the Johns Hopkins University for the degree of Doctor of Philosophy, by George Owen Squier, Lieutenant of Artillery, U. S. A.

This investigation was made under the supervision of Professor Rowland, who, after Professor Remsen's discovery in 1881 of the remarkable influence of magnetism on the deposition of copper from one of its solutions on an iron plate, experimented with Dr. Bell upon the "protective action" of points and ends of magnetic electrodes, and gave the mathematical theory of this action.

The principal results of Lieut. Squier's investigation are summarized as follows:

Whenever iron is exposed to chemical action in a magnetic field, there are two directly opposite influences exerted.

(*a*) The direct influence of the magnetized condition of the metal, causing the more strongly magnetized parts to be protected from chemical action.

(*b*) The indirect influence of the magnet caused by the concentration of the products of the reaction about the more strongly magnetized parts of the iron.

This tends to produce a higher potential at the more strongly magnetized parts and finally establishes permanent electric currents which go in the liquid from the more strongly magnetized to the neutral parts of the iron.

N. M. T.

ALTERNATING CURRENTS OF ELECTRICITY; THEIR GENERATION, MEASUREMENT, DISTRIBUTION AND APPLICATION. By Gisbert Kapp, C. E. With an introduction by Wm. Stanley, Jr. 1893. The W. J. Johnston Co., Ltd., 41 Park Row, New York City. Price, $1.00.

This little book gives an easy and clear description of the graphical methods of the representation of alternating currents and, in the appendices, some mathematical deductions.

As stated by Mr. Stanley in his introduction to the book, it treats in a simple and yet effective manner of periodic currents in general, of the phase relations of impressed and induced electromotive forces possible in simple circuits, of alternating machines, of transformers, of the parallel coupling of alternators, of alternating current motors, of self-starting motors, and finally of multiphase currents.

The reader closes the book with surprise that so much has been so clearly presented in 150 pages, and with the wish that the author would extend and enlarge his treatment of this important subject. N. M. T.

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AMERICAN.

CASSIER'S MAGAZINE.

VOLUME III., No. 17, MARCH, 1893. Electricity and Our Coast Defenses. Modern Gas and Oil Engines. The Life and Inventions of Edison (continued). Practical Notes on the Steam Jacket. W. F. W.

IRON AGE.

VOLUME LI., No. 10, MARCH 9, 1893. Hydraulic Power Plant of U. S. Coast Defense Vessel Monterey. The New Shipping Bounty Laws of France.

MARCH 16. Hydraulic Machinery and Heavy Guns.

The effect of cold weather on the machinery for handling very heavy guns illustrated by the disabling of the Benbow.

Screw Propeller; Easy Method of Measuring the Pitch. The Cunard Steamship Campania. Machinists in the Navy (editorial).

MARCH 23. British War-Ship Construction.

Work done under the Naval Defense Act of 1889.

Trial of Dynamite Gunboat Vesuvius.

MARCH 30. Trial of Dynamite Gunboat Vesuvius (continued).

The Rapieff fuse and its trial.

The Torpedo-Boat Destroyer. The Development of the Injector.

An account of Giffard's invention and its later development.

Notes on British Armor and Ordnance.

APRIL 6. The Merriam Percussion Fuse.

Detailed account with illustrations.

APRIL 13. One Hundred and Thirty Ton Shears at the Maryland Steel Company's Works. The Davis-Farrar Triple-Expansion Engine.

APRIL 20. Merchant Cruisers and Government Subsidies. The Lee Piston Head. The Manufacture of Rifles.

Abstract of paper by the Superintendent of the Enfield Factory.

APRIL 27. Bilge Strainers and Grease Extractors for Sea-Going Ships.

MAY 4. The New Western Electric Generator and Motor. The British Admiralty List of Reserved Merchant Cruisers.

MAY 18. The Allis Quadruple-Expansion Engine at the World's Fair. Smokeless Powder. A New Explosive (Maximite). A New Process of Tempering Steel. The Naval Review Fleets.

MAY 25. The Gatling-West Rifle. An Important Consideration in the Design of Boilers with Curved Back Heads.

JUNE 1. Spring-Return 12-Inch Mortar Carriage.

A combination of a Russian and English design.

The Dow Compound Steam Turbine. C. M. K.

JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

VOLUME V., No. 1, FEBRUARY, 1893. Method of Running the Lines for the Shafting and Boring out the Stern Tubes and Brackets of the U. S. S. Cincinnati. Alignment of Shafting and Boring out Stern Tubes at the Union Iron Works. Steel Castings. Economical Speed and Coal Endurance of War Vessels. Contract Trial of the U. S. S. Monterey. High Smoke Pipes.

Memorandum stating the advantages gained by making the smoke pipes of Armored Cruiser No. 3 100 feet high instead of 60 feet.

Ships (U. S.). Particulars of Bids for the Construction of Armored Cruiser No. 3 (Brooklyn) and Sea-Going Battleship No. 1 (Iowa). Launch of the Katahdin (Harbor Defense Ram) at Bath. Successful Trial of the Bancroft and Speed Curves (mean speed for four hours, 14.37 Knots).

MAY. Experimental Comparison of a Single-Cylinder Engine with a Triple-Expansion Engine. Circulating Pumps. Experiments on the Arrangement of the Surface of a Screw Propeller. Marine Boilers. Supports for Boring Bars for Stern Tubes and Struts. The Worthington Marine Feed-Water Heater. Steam Pipes. The Contract Trial of the U. S. S. Bancroft. The Cunard Steamer Campania. Marine Boiler Furnaces. The Transmission of Heat Through Tube Plates. Effect of Auxiliaries on Economical Speed. Notes: Ships; Merchant Steamers. W. F. W.

JOURNAL OF THE FRANKLIN INSTITUTE.

VOLUME CXXXV., No. 807, MARCH, 1893. Duty Trials of a Pumping Engine. A New Process for the Manufacture of Manganese on the Commercial Scale. Manganese Steel.

Mr. Howe concludes his article on manganese steel and its treatment. He suggests a possible use for it in armor, and from tests of a 2-inch

plate finds that its resistance is 48 per cent. greater than carbon steel. Its enormous and very constant electric resistance suggests important applications in electrical engineering.

Resistance to Ship's Motion.

APRIL. The Modern Travelling Crane.

Description of the 100-ton high-speed electric crane in the new erecting shops of the Baldwin Locomotive Works. Its span is 74 feet 8 inches; length of run-way, 336 feet; speeds (under absolute control) as follows: bridge travel, 100 and 200 feet per minute; trolley travel, crosswise, 50 and 100 feet per minute; hoisting and lowering, 5, 10, 20 and 50 feet per minute.

Resistance to Ship's Motion (continued).

MAY. Duty Trials of a Pumping Engine. Test of a One Hundred Horse-Power Gas Engine Using Producer Gas. Resistance to Ship's Motion (concluded).

JUNE. The Scientific Expert in Forensic Procedure. Rope-Power Transmission. A New Method of Reducing Metallic Oxides. H. S. K.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

MAY, 1893. The Evolution of Modern Drill Books (continued). Military Misconceptions and Absurdities. The Post Mess. The Flag of Truce.

A short article on the rules of intercommunication between belligerents under the flag of truce, and quotation of precedents.

Apprentice Schools for the Army. Military Uses of Photography. Target Practice. The Evolution of Tactics (trans.). H. S. K.

JOURNAL OF THE UNITED STATES ARTILLERY.

VOLUME II., No. 2, APRIL, 1893. Theoretical Discussion of the Brown Segmental System of Wire Gun Construction.

Lieut. Whistler, 5th Artillery, gives a thorough discussion of the system under the two heads of *General Discussion* and *Mathematical Discussion*. The general reader will be satisfied with the first part, which is complete in itself, except in so far as mathematical proof is needed for certain claims set forth.

The Artillery-Fire Game (trans.). Artillery Note; Answer to a Pamphlet issued by Armstrong & Co. in November, 1892, on R.-F. Guns (trans. from the French).

This paper is written in the interest of the Canet gun system, and is valuable in connection with the special number (Vol. I., No. 5, J. U. S. A.), which dealt very fully with the matter of English, French and German R.-F. guns. H. S. K.

JOURNAL OF THE U. S. CAVALRY ASSOCIATION.

VOLUME VI., No. 20, MARCH, 1893. Smokeless Powder in its Relation to Cavalry Efficiency. Some English Views of the

Mounted Action of the American Cavalry. The New Revolver. Professional Notes: Revolver Practice; Correct and Quick Pointing. H. S. K.

SCHOOL OF MINES QUARTERLY.

JANUARY, 1893. Comparison of Cost of Electric Lighting of Columbia College by Separate Plant and by Contract with Companies.

The article shows that the cost of lighting by separate plant is *one-fifth* the cost of the same light furnished by contract.

W. F. W.

THE STEVENS INDICATOR.

VOLUME X., No. 1, JANUARY, 1893. The Whitehead Torpedo.

A brief general description of the Whitehead automobile.

A New Recording Pressure Gauge for Extremely Low Ranges of Pressure. Cost of Castings. H. S. K.

FOREIGN.

ANNALEN DER HYDOGRAPHIE UND MARITIMEN METEOROLOGIE.

XXI. ANNUAL SERIES, 1893, VOLUME II. Drift Ice in Southern Latitudes. On Light Houses and Light Beacons (with Table). Sailing Route from Newcastle, N. S. W., to San Diego, Cal. A Rich Whale-Catch in the Arctic Ocean. Whaling in the Pacific Ocean and Bering Sea during the Decade 1860–1870. Observations on the Approach to Chemulpo, Corea. The Harbors of Casablanca and Magador, Morocco. A Voyage from Teneriffe to Bahia. Minor Notices: The Antarctic Whaling Fleet; Time Ball at Rio Janeiro; Meteorological Publications; New Regulations for Navigation on the Rivers and Streams of the Netherlands; On the Depth of Water in the Woosung River; Magnetic Observations on the East Coast of Siberia.

Meteorological Journals received at the German Obvervatory during the Month of January, 1893.

The Weather on the German Coast in January, 1893 (with Tables).

VOLUME III. Remarkable Tropical Revolving Storms in the Southern Indian Ocean. New Sea-Canals. Hydrographic Work in the Vicinity of the Eastern Entrance to Magellan Straits. Criticism of the Essay, "The Principal Atmospheric Currents." Voyage from Singapore to Colombo. Voyage from Hong Kong to Amoy, thence to Shanghai. Grenada. The State of the Water-Tides, and Pilotage in the Woosung River. Notes on San Diego, Cal. Voyage from Cardiff, England, to Port Pirie, S. Australia, thence to Newcastle, N. S.W. Climate of Madras. Minor Notices: Water Spouts in the North Atlantic.

Meteorological Journals received at the German Observatory in February, 1893.

The Weather on the German Coast for February, 1893 (with Tables).

VOLUME IV. The Harbor of Kunachee. The Action of Oil and Soapy Substances on Water in Calming the Waves. Extracts from the Cruising Report of Dr. Plehn of a Voyage to East Asia on the Steamer Priok. Drift Ice in Southern Latitudes (continuation). Rules Governing the Spelling of Geographical Names in Germany. Modern Meteorology.

Minor Notices: System of Observation-Terms Adopted in Germany; First Award of the Buys Ballot Medal; Shoals in Monte Christo Bay, San Domingo; Meteorological Observations on the Hawaiian Islands.

Meteorological Journals received at the German Observatory, March, 1893.

The Weather on the German Coast in March, 1893 (with Tables).

H. O.

BOLETIN DEL CENTRO NAVAL.

VOLUME X., DECEMBER, 1892. Modern Constructions; Plan of a Rapid Cruiser (continued). Tables for Calculating the Latitude by Means of Circumeridian Altitudes. The Naval School; Report of the Board of Examiners.

JANUARY and FEBRUARY, 1893. The Naval School. Reckoning Latitude at Sea. Modern Constructions; Project of a Rapid Cruiser (continued). Saving of Vessels in General; Means Applied in Rescuing the Howe. Compendium of Instructions for Gunnery Ships and Torpedo Stations in the Italian Navy.

J. L.

DEUTSCHE HEERES-ZEITUNG.

FEBRUARY 18. Rapid-Firing Guns.

A brief review of their development in recent years, their effect on naval construction and tactics, and their adoption in the German navy.

Preserved Food; Its Use and Value in War.

FEBRUARY 22. The Organization of the Engineer Corps of the Italian Army. Officers' Pensions in the Different European States. Preserved Food; Its Use and Value in War (conclusion).

FEBRUARY 25. French Auxiliary Cruisers.

The requirements of the French Government and the preparations made to convert merchant steamers into auxiliary men-of-war, with a brief account of the recent mobilization of the steamer La Normandie.

MARCH 4. The German Plan of Naval Reconstruction.

A criticism of the plan adopted in 1888.

The French Manœuvres of 1893.

MARCH 11. Russian Black Sea Fleet.

APRIL 8. The United States Navy.

A brief description of the vessels lately built for the U. S. navy.

APRIL 12. The Reconstruction of the German Navy.

A brief review of changes in the vessels and armaments.

APRIL 19. The Ram in the United States Navy,

A criticism of the use of this type of vessel, and a description of the Ammen and Folger rams.

The Trials of the 6-cm. Krupp Rapid-Firing Field Guns of 30–38 Calibers, which Took Place near Meppin, Oldebrock and Schwingen, from 1889–1892.

APRIL 22. The Trials of the 6-cm. Krupp Rapid-Firing Field Guns, etc. (continuation).

APRIL 26. The Trials of the 6-cm. Krupp Rapid-Firing Field Guns, etc. (continuation).

The Fleets of the Naval Powers in 1853–54.

APRIL 29. The Trials of the 6-cm. Krupp Rapid-Firing Field Guns, etc. (conclusion). H. O.

THE ENGINEER.

MARCH 3, 1893. Bridging the Bosphorus.

Mr. James Garvie proposes bridging the Bosphorus, in connection with a system of projected railways centering in Constantinople. The width of the Bosphorus where the proposed bridge is to be placed is about 2200 yards, and the land is high on each side, so that a height of 220 feet above low water level could easily be provided.

History of the Cunard Steamship Company. Second Class Cruisers Sappho and Scylla. The Entrance to Colombo Harbor. U. S. Battleship Iowa. Machinery Trials of H. M. Torpedo Gunboat Circe.

MARCH 10. The Launching of the Campania and Lucania. Southampton and the American Line of U. S. Mail Steamers. History of the Cunard Steamship Company (concluded).

MARCH 17. U. S. Battleship Indiana. Mechanical Flight (Maxim). The Efficiency of Steam Engines.

MARCH 24. The Institution of Naval Architects. Mudd's Arrangement of Condenser Tubes. The Italian Cruiser Marco Polo. The Bearing of Recent Plate Trials on Future Warfare. The Russian Official Report on the Ochta Competition. Root's Oil Engine.

MARCH 31. Weir's Feed-Water Heater. The Flensburg Off-Shore Floating Dock. Harbors and Waterways.

APRIL 7. American Nickel Harveyed Plate Trial. Light Marine Boilers. Calorimetric Determination of Coal.

Description of the Mahler apparatus and method.

APRIL 14. Roller and Ball Bearings. The United States Navy. The Fastest Paddle Steamer in the World (Leopold II.). The Draughtometer.

An instrument designed to show the draught from inboard, and even on deck, by means of an ingenious electrical attachment.

Sutherland's Electric Deck Planer. Ross' Steam and Pneumatic Caulking Tool. Umpires' Report on the Naval Manœuvres, 1892. The Daimol Petrol Motor.

APRIL 21. The U. S. Dynamite Cruiser Vesuvius. The Propulsion of Ships. Kirkaldy's Compactum Evaporator Feed-Water Heater.

APRIL 28. United States Atlantic Liners. Compound Marine Engines. Priestman's Petroleum Engine.

MAY 5. Shipbuilding in France. Trial of a Triple-Expansion Condensing Engine. Copper for Fireboxes. Trials of H. M. SS. Ramillies and Alarm. The Rocket Petroleum Engine.

MAY 12. Harbors and Waterways. Ignition Tubes for Gas Engines. The Analysis of Engine Tests. A New Electricity Meter. Trial of H. M. S. Empress of India.

MAY 19. The Report of the Navy Committee on Boilers. Human's Logarithmic Co-ordinate Sheets. Lessons Learnt at Sea by a Marine Engineer. Italian Naval Progress. Ship Canals.

MAY 26. H. M. S. Speedy. Dassen Island Lighthouse. Bronze Screw Propellers. Mudd's Tail Shaft Preserver. The Ejector Condenser. Trial of H. M. S. Crescent. H. S. K.

ENGINEERING.

VOLUME IV., NO. 1418, MARCH 3, 1893. The Development and Transmission of Power from Central Stations.

MARCH 10. The Engines of H. M. SS. Circe, Alarm and Lida. The Desroziers Continuous Current Dynamo. H. M. S. Blenheim.

Mr. W. H. White discusses the trials of the Blenheim and claims 22½ knots speed for a forced draught four hours' continuous sea speed.

The American Line of Steamers. Mechanical Flight. Alloys. Notes: New Docks at Portsmouth; Naval Engineers; The United States Ram Katahdin; The Trials of the Repulse; High-pressure Hydraulic Presses in Iron Work.

MARCH 17. Alloys. Trials of H. M. S. Vulcan. Experimental Apparatus at Haslar.

Description of the experimental apparatus and shaping machine for ship models at the Admiralty Experiment Works, Haslar.

MARCH 24. The Austrian Torpedo Cruiser Satellit.

On her trial run made 22.5 knots, 1.5 knots more than contract requirements.

Engineering Theory and Practice. Alloys. The Institution of Naval Architects.

Notice of the annual meeting, the address of the President, and of papers by Rear-Admiral Samuel Long and Lord Brassey on The Position of Cruisers in Warfare, and Merchant Cruisers Considered with Reference to the Policy of Maintaining a Reserve of Vessels by Annual Subventions to Shipowners, respectively.

Efficiency of Dynamo-Electric Machines. Some Mechanical and Electrical Analogies.

MARCH 31. The Institution of Naval Architects (continued).

Notice of papers on The Strength of Bulkheads, Measurements of Wake Currents, Propulsion of Ships, The Transmission of Heat through Tube-plates (published in full on another page), Alterations in Boilers under Pressure, Vibrations of Steamers, Repairs of Ships, and Curves of Stability.

The American Inventor. Quick-Firing Guns in the Field. Alloys. American Institute of Mining Engineers.

Notice of the Greene-Wahl process for manufacturing manganese and its alloys free from carbon.

APRIL 7. The Institution of Naval Architects. European Canals. The Use of Superheated Steam in Steam Engines. Harmonic Valve Diagram. The Measurement of Wake Currents. The Strength of Bulkheads.

APRIL 14. The Murren Wire-Rope and Electric Mountain Railway. The Nicaragua Canal (continued). Boat Railway at Meaux, France. Merchant Cruisers. Merchant Cruisers Considered with Reference to the Policy of Maintaining a Reserve of Vessels by Annual Subventions. The Vibrations of Steamers.

APRIL 21. The Cunard Royal Mail Twin-Screw Steamers Campania and Lucania. The World's Columbian Exposition, 1893. Shipbuilding on the Thames. Speed Trials of the Campania. The Condition of the Shipbuilding Trade.

This very handsome number is of especial interest from its very full description of the two latest additions to the Cunard fleet, and also of the Columbian Exposition. Both articles are very complete and are admirably illustrated, occupying together about 130 pages. The former deals with the design, the hulls, the launch, construction of engines and boilers, electric lighting, navigating appliances, passenger accommodations, ventilation, commissariat, refrigerating plants, and cargo appliances; the latter opens with a brief notice of the four trunk lines connecting New York and Chicago, and, after a short historical sketch of the Exposition and of the city in which it is to be held, goes on to describe in detail the more important buildings, closing with a description of the means of communication. A reprint has since been published, price 6s.

APRIL 28. The Nicaragua Canal. Institution of Mechanical Engineers.

Notice of meeting, and discussion of the two papers read, viz., Copper Plates for Locomotive Fireboxes, and Alloys. The former is published in full, and the latter (which is the second report of the Alloys Research Committee) is begun in another part of this issue.

United States Cruiser Olympia. Trial of H. M. S. Ramillies.

MAY 5. English and American Locomotives. Compound Engines of the Japanese Cruiser Unebi. The Strength of Basic Bessemer Steel Joists. Phillips' Flying Machine. Iron and Steel in Sweden. Trial of H. M. S. Ramillies. Alloys (continued).

MAY 12. The Report of the Admiralty Boiler Committee. Alloys (concluded).

MAY 19. Boilers in the Navy. H. M. S. Speedy. Power Trials of H. M. S. Ramillies. On Some Experiments with the Engines of the S. S. Iveagh.

Two four hour runs were made under different conditions. In the first, the engines were run as compound, the intermediate cylinder being disconnected; in the second, all three were in action. The boiler efficiency was the same in both. While the arrangement of cylinders, cut-offs, etc., in the compound arrangement was not the most favorable, the results show that with 2 lbs. more boiler pressure on the second trial, three additional revolutions, 0.24 knot more speed, and 80 additional H. P. were attained, the consumption of coal falling from 134 to 94 lbs. per nautical mile.

The Cyclogram. Fixing Boiler Tubes. Machinery Trials of H. M. S. Empress of India.

MAY 26. A New Type of Cargo Steamer. Naval Engine-Room Efficiency. Explosives. The Iron and Steel Institute.

Report of the Council and address of the President.

Alterations of Form of Boilers under Steam. The Manufacture of Small-Arms. H. S. K.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

VOLUME XXXVII., No. 180, FEBRUARY, 1893. The System of Mounting and Placing Guns on board Ships of the Royal Navy. By G. O. Arnold-Foster, M. P.

Mr. Arnold-Foster criticises the placing rather than the mounting of guns as generally found in British ships. His two special points are the placing of guns in pairs in turrets or barbettes, and the small average height of heavy guns above the water-line, both of which he considers very faulty, instancing French practice in support of his views. Very naturally his views are not generally endorsed in the discussion.

France and Her Marine (Mercantile and War) (trans.). Recent Progress in Marine Machinery (trans.). Moltke's Tactical Exercises, 1858–82.

MARCH, 1893. Electric Balloon Signaling. The Different Systems of Signaling in the Field. The Buonaccorsi Automobile Torpedo (trans.).

The Magazine Rifle of 6.5 mm. (0.2569 in.) Calibre, Mannlicher System (trans.).

APRIL, 1893. The Military Organization Best Adapted for Imperial Needs. Engine-Room Telegraph (trans.). England's Position in the Mediterranean (trans.). French Small-arm Smokeless Powder.

MAY. The Military Organization Best Adapted to Imperial Needs. Modern Warfare as Affecting the Mercantile Marine of Great Britain.

Lieut. Crutchley, R. N. R., advocates the partial arming of merchantmen for the purpose of self-protection.

Our Swordsmanship.

This lecture by Captain Hutton has attracted considerable attention in England. In it he criticises with considerable particularity the methods in use in the English army, and lays to their charge the lack of interest in the subject among officers which he so greatly deplores.

The Contemporary Navies of the European Powers. The Battleships of England. The Russian Official Report on the Ochta Competition. Experimental Firing with the 6-cm. Q.-F. Field Guns at the Krupp Works in Germany. Naval and Military Notes.

H. S. K.

MILITÄR-WOCHENBLATT.

FEBRUARY 18. Army Reorganization and Military Service in Switzerland. The New Recruiting Law of Italy. Historical Sketch of the Russian Military Institutions.

FEBRUARY 22. Army Reorganization and Military Service in Switzerland (conclusion). The Condition and Strength of the Austro-Hungarian Army.

FEBRUARY 25. The Present Organization and Strength of the French Infantry. The Preparation of Provisions in War. Cooking Schools in the English Army.

MARCH 18. The Condition of the Russian Army for War. Military Schools of Switzerland in 1893.

MARCH 22. The Condition of the Russian Army for War (conclusion).

MARCH 27. The Law in Regard to the Superior Council of War of France.

MARCH 29. The Bulgarian Army and its Budget for 1893.

APRIL 1. The Stranding of H. M. S. Howe.

A brief review of the circumstances attending the stranding of the Howe at the entrance to the harbor of Ferrol, and of the result of the trial of her commander and navigating officer.

APRIL 5. The Stranding of H. M. S. Howe (conclusion).

A review and criticism of the result of the trial of Vice-Admiral Fairfax, the Commander-in-Chief of the Channel Squadron.

Dahomey.

APRIL 8. The Military Service of Germany in the War with France, 1870–71.

APRIL 12. Same (continuation).

APRIL 15. Same (conclusion).

APRIL 19. Military Statistics of the Franco-German War of 1870–71. A Naval War of the Future.

A criticism of Mr. Laird Clowes' recent publication "The Mary Rose."

APRIL 20. The Reorganization of the Military School of Portugal.

APRIL 29. Fire-Practice of Infantry to Solve Certain Tactical Questions. A New French Cruiser.

A description of the Descartes.

MAY 17. Casualties in the Principal Battles of the Last Hundred Years.

A refutation of the article under the above title, which appeared in the Prussian Annual of April last.

Wire-Wound Guns.

A review of the different guns constructed on this system, and a description of the latest Brown segmental wire-wound gun.

MAY 20. Casualties in the Principal Battles of the Last Hundred Years, etc. (conclusion).

SUPPLEMENT TO MILITÄR-WOCHENBLATT.

VOLUME 344. The Impressions of a Military Tourist in the Caucasus and Southern Russia, by Captain V. Drygalski of the German Cavalry. H. O.

MINUTES OF PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS.

VOLUME CXI. Halifax Graving Dock. Biloela Graving Dock, Cockatoo Island, Sydney Harbor, N. S. W. Alexandra Graving Dock, Belfast. Construction of a Concrete Graving Dock at Newport, Mon.

These papers give more or less full descriptions of the several docks mentioned, and a discussion on the general subject follows.

The Manufacture of Small-Arms.

Mr. Rigby's paper is a full description of the methods of small-arm manufacture at the Royal Small-Arms Factory, Enfield. It is very fully discussed, and the article and discussion are very interesting reading.

Relative Power of Lighthouse Lenses. The Port of Genoa. Method of Coppering Ships by Deposition. The National Small-Arms Factory at Liége. H. S. K.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XXI., Nos. 1 and 2. The Steam Commerce of Austro-Hungary. The Fundamental Laws of Astronomy from a New Point of View (a study). The Latest Method of Determining the Deviation of the Compass, and of the Compensation of the Compass by Bearings of an Indeterminate Object. Naval Manœuvres of 1892. A Comparison Table of the Most Reliable Data of the 10-cm., 12-cm. and 15-cm. Rapid-Firing Guns of the Following Systems: Armstrong, Canet, Hotchkiss, Krupp, Maxim-Nordenfeldt and Schneider. Naval Budget of Russia for 1893. The Stranding of the Howe off Ferrol. The New Compass-Card of Dr. P. J. Kaiser of Leyden. A New Rocket Apparatus for Life-Saving. The Acceptance Trials of the Chilian Armorclad, Captain Pratt. Smokeless Coal Consumption. The Use of Naphtha on Warships and Torpedo-Boats.

No. 3. The Stability of the Axis of Rotation, Especially as Regards the Howell Torpedo (a study). The Annual Report of the Engineer-in-Chief of the United States Navy. The Naval Budget of England for 1893–94. Trial Runs of the Danish Cruiser Geiser. The Steam Tests of the Towne Boiler, with Table of Results. H. O.

LE MONITEUR DE LA FLOTTE.

No. 19, MAY 13. New Navy Constructions.

MAY 20. Wireless Electric Communications Between Ships at Sea.

"In a late communication, read before the Royal Association of Edinburgh, upon long distance induction through air and water without the use of parallel wires, Mr. Stevenson proposes a method that may prove useful in establishing electric communications between ships at sea."

J. L.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

MARCH, 1893. Okehampton Experiences, 1892 (Artillery Practice).

"*Cordite.* The great difficulty that has attended the introduction of cordite is that of securing a suitable vent and friction tube. The rush of gas, if unchecked, is so violent that the ordinary steel vent gutters away and is unserviceable after a few rounds (varying from 10 to 30). Apparently, the only way out of the difficulty lies in some form of vent-sealing tube. More than a dozen different forms have been tried, but as yet without very much success, and it has been found difficult, so far, to design anything that will be both effective as a vent-sealer, and at the same time not so clumsy as to effect the service of the gun."

Recent Development of Armor and its Attack by Ordnance (concluded).

Notes the Elswick experimental gun of 100 calibres which gave a 100-lb. projectile a velocity of 3231 f.-s., and a 70-lb. projectile 3711 f.-s.; the Ochta trials of armor in November and December, 1892; and discusses briefly the attack of ships.

APRIL. The Strategical Geography of Europe. Notes on Optical Instruments. The Value of a High Site for Coast Artillery.

MAY. The Effect of the Rotation of the Earth on the Motion of Projectiles.

A short mathematical paper of theoretical interest only; the assumption is made that gravity is constant in magnitude and direction throughout the flight of the projectile.

Modern Gunpowder and Cordite.

An interesting lecture.

The Military and Naval Power of the United States (trans.).

H. S. K.

REVISTA TECNOLÓGICO INDUSTRIAL.

NUM. 1., AÑO 16, JANUARY, 1893. Resistance of Materials; a Study of the Tests of Iron and Steel.

Lecture delivered by M. E. Cornut in the Congress of Applied Mechanics (continued).

Descriptive and Rational Chemistry.

Address read at the opening of the Academic Course, 1892–93, in the University of Madrid.

J. L.

REVUE DU CERCLE MILITAIRE.

NO. 20, MAY 14. A Manœuvring Column in the South-Oran (Africa). The Infantry Armament and Prof. Hebler's Formula (ended). The Servian Army (ended).

MAY 21. The Naval Review and Parade in New York. A Military Co-operative Association in Russia. J. L.

REVUE MARITIME ET COLONIALE.

VOLUME CXVI., MARCH, 1893. Cruisers; Their Rôle; The Conditions they Must Fulfill (by Vice-Admiral de Cuverville). Historical Notice of the Trial Board of Artillery at the Gâvre Proving Grounds (continued). A Study of the Mechanical Theory of Heat (continued). The Actual State of the National (French) Navy. Circulation of Wind and Rain in the Atmosphere. Utilization of Screw Propellers. In the Land of the Kanacks; New Caledonia and its Inhabitants in 1890. The United States Navy (trans.).

MAY. A Study of the Theory of Naval Warfare. Cruisers.

"The writer, E. Guiffort, an Ensign in the French navy, who lost his life in the wreck of the Labourdonnais in a cyclone at Madagascar, in February last, is convinced that the modern fast cruisers will play a very important strategic as well as tactic part in the next wars. The present study aims to show the nature of the duties assigned to them and hints at the changes that will take place in actual combat as well as in subsequent manœuvres."

Simultaneousness of Gun Loading and Firing (with a full description of the apparatus). Mechanical Solutions of Problems in Navigation. Circulations of Wind and Rain through the Atmosphere. Two New Theorems in Physical Astronomy in Regard to the Unequal Distribution of Heat upon the Surface of the Northern and Southern Hemisphere of the Terrestrial Globe. J. L.

REVISTA DI ARTIGLIERIA E GENIO.

VOLUME I., FEBRUARY, 1893. Advance in the Art of Modern Cartography in Europe. Artillery Drill in the German Army. Considerations on the Fire Probability in Ship and Coast Batteries (continued).

MARCH. Advance in the Art of Modern Cartography in Europe (ended). Considerations on the Fire Probability in Ship and Coast Batteries (six plates). The Method of Indirect Firing in Field Artillery.

VOLUME II., APRIL. A Brief Consideration of the Field Artillery Regulations. Temporary Fortifications and the New Means of Attack. Fuses and Detonators in Use in German Artillery (1 plate). Instructions in Carrying Out Fire Practice. J. L.

THE STEAMSHIP.

VOLUME IV., No. 46, APRIL, 1893. Delta White Anti-Friction Metal Tests.

Table of results of tests made by Professor W. C. Unwin.

Cumming's Shaft Leveller.

An instrument specially designed for testing the alignment of propeller shafts on shipboard; it is simple and effective.

W. F. W.

UNITED SERVICE GAZETTE.

FEBRUARY 25, 1893. Egypt and the Red Sea.

MARCH 4. The Admiralty and the Stranding of the Howe. The Navy Estimates. Strategy in the American Civil War.

MARCH 18. The State of the Navy.

MARCH 25. M. Weyl on the Recent Admiralty Minute. The Naval Manœuvres, 1891, I. The Manning of the Navy.

APRIL 1. Field Guns. Military Law. Engine-Room Artificers. The Naval Manœuvres, 1892, II. Our Need of Cruisers. Smokeless Powder in Warfare.

APRIL 8. Naval Supremacy.

APRIL 15. The Value of the Torpedo-Boat. Imperial Defense.

APRIL 22. Our Position in the Mediterranean. The Invasion of England.

APRIL 29. The Future of the Torpedo.

MAY 6. Our Relative Strength at Sea. Continuity of the Effective Service of Warships. Photographing Flying Bullets.

MAY 13. The Personnel of the Navy.

MAY 20. Our Naval Strength.

MAY 27. Our Naval Requirements. H. S. K.

LE YACHT.

NO. 792, MAY 13. The Naval Review and Boat Races at New York.

MAY 20 and 27. The Contemplated New Armorclads (E. Weyl). J. L.

EXCHANGES, BOOKS AND PERIODICALS RECEIVED.

ALTERNATING CURRENTS OF ELECTRICITY.
AMERICAN CHEMICAL JOURNAL.
AMERICAN ENGINEER AND RAILROAD JOURNAL.
ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE.
ANNUAL REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY, 1892, PARTS 1, 2, 3 AND 4, AND ATLAS.
ARMY AND NAVY REGISTER.
BOLETÍN DEL CENTRO NAVAL.
BULLETIN OF THE AMERICAN GEOGRAPHICAL SOCIETY.
BULLETIN OF THE AMERICAN IRON AND STEEL ASSOCIATION.
BULLETIN OF THE GEOGRAPHICAL SOCIETY OF CALIFORNIA.
CASSIER'S MAGAZINE.
CIVILIZATION AMONG THE SIOUX INDIANS.
COLLIERY ENGINEER.
DEUTSCHE HEERES-ZEITUNG.
ELECTRICAL REVIEW.
ELECTRICITY AND MAGNETISM OF ADVANCE PRIMERS OF ELECTRICITY.
ELECTRO-CHEMICAL EFFECTS DUE TO MAGNETIZATION.
ENGINEER, NEW YORK.
ENGINEER, LONDON.
ENGINEERING, LONDON.
ENGINEERING-MECHANICS.

Engineering News and American Railroad Journal.
Index to the Literature of Explosives, Part II.
Iron Age.
Journal and Proceedings of the United Service Institution of New South Wales.
Journal of the American Society of Naval Engineers.
Journal of the Association of Engineering Societies.
Journal of the Franklin Institute.
Journal of the Military Service Institution.
Journal of the Royal United Service Institution.
Journal of the United States Artillery.
Journal of the United States Cavalry Association.
Lend-a-Hand.
Marine Review.
Militär-Wochenblatt.
Minutes and Proceedings of the Institution of Civil Engineers.
Mittheilungen aus dem Gebiete des Seewesens.
Mémoires et Compte Rendu Des Travaux De La Société Des Ingénieurs Civils.
Le Moniteur de la Flotte.
Norsk Tidsskrift for Sovaesen.
Pacific Militant, Vol. I., Nos. 1 and 5.
Proceedings of the American Academy of Arts and Science.
Proceedings of the American Philosophical Society.
Proceedings of the Institution of Mechanical Engineers.
Proceedings of the Royal Artillery Institution.
Railroad Gazette.
Revista Maritima Brazileira.
Revista Tecnológico Industrial.
Revue du Cercle Militaire.
Revue Maritime et Coloniale.
Rivista Marittima, Rome.
School of Mines Quarterly.
Statistics of the American and Foreign Iron Trades for 1892; Annual Statistical Report of the American Iron and Steel Association.
Steamship.
Technology Quarterly and the Proceedings of the Society of Arts.
Teknisk Tidskrift.
Tidskrift i Sjöväsendet.
Transactions of the American Society of Civil Engineers.
Transactions of the North of England Institute of Mining and Mechanical Engineers.
Transactions of the Technical Society of the Pacific Coast.
U. S. Geological Survey; Mineral Resources of the United States.

United Service Gazette.
United Service.
World's Fair Electrical Engineering.
Le Yacht.

REVIEWERS AND TRANSLATORS.

Lieut.-Comdr. J. P. Merrell.
Lieutenant Hugo Osterhaus.
P. A. Engineer W. F. Worthington.
Ensign C. M. Knepper.
Professor N. M. Terry.
Professor Jules Leroux.
Lieutenant H. S. Knapp.

NAMES OF MEMBERS WHO HAVE JOINED SINCE JULY, 1892.

Regular Members.

Benson, Wm. S., Lieutenant, U. S. Navy.
Berry, David M., Naval Cadet, U. S. Navy.
Bisset, Eugene L., Naval Cadet, U. Navy.
Brady, J. R., Naval Cadet, U. S. Navy.
Campbell, E. H., Naval Cadet, U. S. Navy.
Carver, Marvin, Naval Cadet, U. S. Navy.
Clark, F. H., Naval Cadet, U. S. Navy.
Cook, A. M., Naval Cadet, U. S. Navy.
Crosley, Walter S., Naval Cadet, U. S. Navy.
Doddridge, John S., Naval Cadet, U. S. Navy.
Douglas, R. T., Naval Cadet, U. S. Navy.
Elder, E. A., Naval Cadet, U. S. Navy.
Everhart, L. H., Ensign, U. S. Navy.
Fewel, C. C., Naval Cadet, U. S. Navy.
Fitch, Claude E., Naval Cadet, U. S. Navy.
Gise, Wm. K., Naval Cadet, U. S. Navy.
Gove, Chas. A., Lieutenant, U. S. Navy.
Hains, P. C., Naval Cadet, U. S. Navy.
Holsinger, Gerald L., Naval Cadet, U. S. Navy.
Jackson, Orton Porter, Naval Cadet, U. S. Navy.
Lang, C. J., Naval Cadet, U. S. Navy.
McCormick, C. M., Ensign, U. S. Navy.
McKethan, A. A., Naval Cadet, U. S. Navy.
Montgomery, W. S., Naval Cadet, U. S. Navy.
Morris, John R., Naval Cadet, U. S. Navy.
Olmsted, Percy N., Naval Cadet, U. S. Navy.
Parker, Thomas D., Naval Cadet, U. S. Navy.
Perry, Joseph A., Naval Cadet, U. S. Navy.
Peugnet, M. B., Naval Cadet, U. S. Navy.
Pollock, E. R., Naval Cadet, U. S. Navy.
Potter, Jas. Boyd, Naval Cadet, U. S. Navy.
Powell, Wm. G., Naval Cadet, U. S. Navy.
Powelson, W. Van Nest, Naval Cadet, U. S. Navy.
Pratt, Alfred A., Naval Cadet, U. S. Navy.
Procter, A. M., Naval Cadet, U. S. Navy.

Ritter, Henry S., Ensign, U. S. Navy.
Sticht, John Low, Naval Cadet, U. S. Navy.
Stitt, Thomas L., Naval Cadet, U. S. Navy.
Upham, F. Brooks, Naval Cadet, U. S. Navy.
Ward, Henry H., Naval Cadet, U. S. Navy.
Wells, Chester, Naval Cadet, U. S. Navy.
Wilson, Thomas S., Naval Cadet, U. S. Navy.

Associate Members.

Acland, F. E., Captain (Late of the Royal Artillery).
Blackwell, F. O., Lieutenant, Naval Brigade, Mass. V. M.
Bloodgood, W. D., Lieutenant, Naval Battalion, N. G. C.
Borden, Richard P., Ensign, Naval Brigade, Mass. V. M.
Cary, W. A., Lieutenant, Naval Brigade, Mass. V. M.
Cheneau, E., Franco-American Cellulose Co., Philadelphia, Pa.
Crocker, C. H., Lieutenant, Naval Battalion, N. G. C.
Denny, A. B., Ensign, Naval Brigade, Mass. V. M.
Dohrman, H. G., Steubenville, Ohio.
Durfee, Nathan, Lieutenant, Naval Brigade, Mass. V. M.
Garvie, James, M. E., Southgate Engineering Co., England.
Hadfield, R. A., Steel Manufacturer, Hadfield Steel Works, England.
Hayes, Hammond V., Lieutenant, Naval Brigade, Mass. V. M.
Heese, Albrecht, Lieutenant, Royal Prussian Artillery Guards, and Attaché to the Imperial German Legation.
Hervey, Homer W., Naval Brigade, Mass. V. M.
Hey, George W., Counsellor-at-Law, Syracuse, N. Y.
Houghton, Clement, Mass. V. M.
McClymont, E. E., Mechanical Engineer and Naval Architect.
Morgan, Daniel, Maysville, Ky.
Noble, R. H., Lieutenant, 1st Infantry, U. S. Army.
O'Neill, J. J., Naval Architect.
Sprague, Timothy W., Lieutenant, Naval Brigade, Mass. V. M.
Turner, Louis H., Lieutenant, Naval Battalion, N. G. C.
Tyler, Willard C., President and Manager of the Eastern Department of the Railway Review of Chicago.
Williams, Franklin D., Lieutenant and Adjutant, Naval Brigade, Mass. V. M.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1894.

A prize of one hundred dollars, with a gold medal, is offered by the Naval Institute for the best essay presented on any subject pertaining to the naval profession, subject to the following rules:

1. The award for the Prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1894. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Board.

3. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Board.

4. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

5. The essay is limited to fifty (50) printed pages of the Proceedings of the Institute.

6. All essays submitted must be either type-written or copied in a clear and legible hand.

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

H. S. KNAPP,
Lieut., U. S. N., Secretary and Treasurer.

ANNAPOLIS, MD., *January* 3, 1893.